POWER

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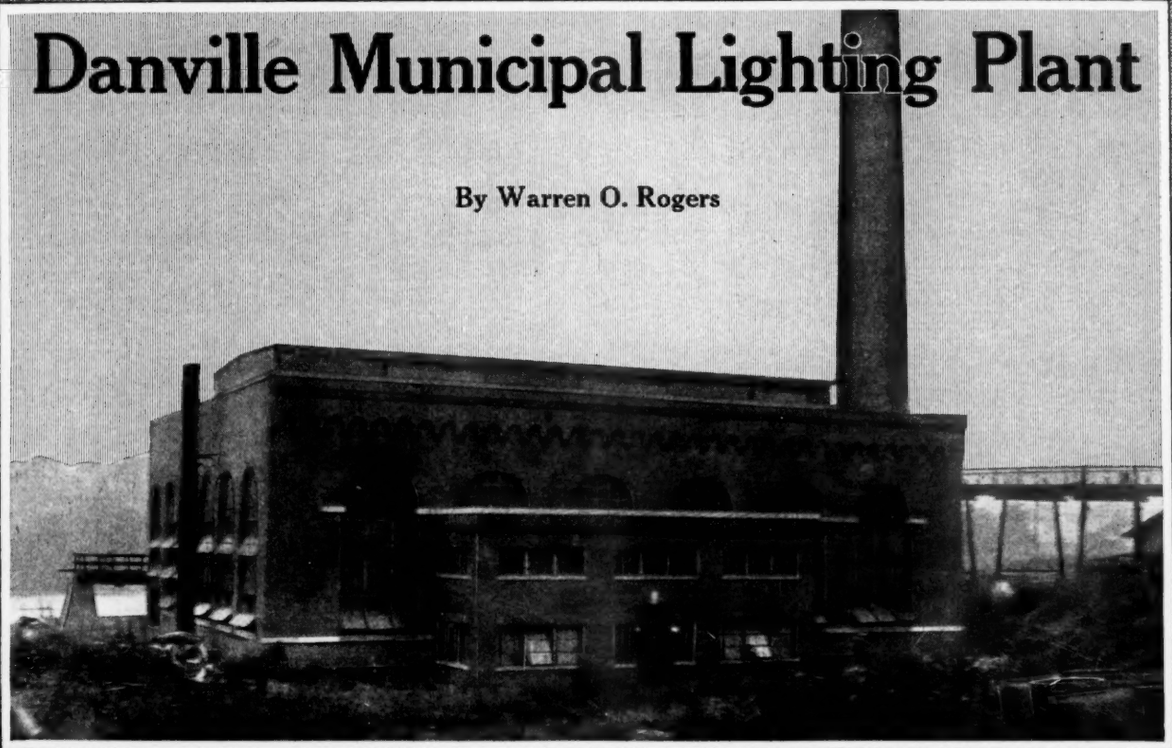
For the sake of the property intrusted to your care, for the sake of the people you serve, and for the sake of yourself—

Forget That Grudge!

Danville Municipal Lighting Plant

By Warren O. Rogers



SYNOPSIS—A municipally operated electric-lighting plant costing $228,913 did a business of $79,936 for the year 1914. The disbursements were $53,030, showing a profit exclusive of depreciation of $26,906. It is a turbo-generator plant with water-tube boilers. Condensing water is obtained from the river, and coal is delivered to the plant on a spur track. The boilers are hand-fired. Steam at a pressure of 190 lb. superheated 150 deg. is carried. The cost of the plant is given in detail.

The City of Danville, Va., has been operating its new municipal electric plant for about three years. It is a turbine proposition and cost $228,913 to build. The city is by no means inexperienced in municipal-plant operation; in fact, Danville has the distinction of being the first city in the United States to own and operate a street-lighting system, about 30 years ago, when the first system was inaugurated. In 1900 the city entered the commercial field of electric lighting, and a small plant was installed to carry a lighting load. In 1911 it was decided to build the present power plant.

The location is close to the Dan River, in the heart of the territory to be served. An abundance of condensing water is available from the river, and coal is delivered to the plant on a spur track at approximately $3.50 per ton.

The building is 100 ft. long and 90 ft. wide. The turbine and boiler rooms are separated by an 18-in. brick wall, giving a width of 45½ ft. to the former and 38 ft. to the latter. At the front of the building is an annex in which are the chief engineer's office, meter and arc-lamp testing rooms, wash and locker rooms.

To provide a railroad siding for receiving coal, it was necessary to carry the track under the Worsham Street bridge, which parallels one side of the property. The grade of the bridge was changed in such a way as to give the increased headroom necessary and at the same time to reduce the maximum grade on the bridge.

The grade of the power station was determined largely by the available elevation of this coal siding, the main floor being placed above the record high-water mark of the Dan River, which is subject to sudden and extreme rises that appear to have gradually grown worse, owing to the deforestation of the watershed. After the station was nearly completed the river rose to a point exceeding all previous records, reaching almost the level of the station floors. It was therefore determined to make the retaining wall, about to be constructed along the river face of the property, of sufficient height to guard against any possible flood, at the same time making it possible to largely increase the coal-storage space.

To provide for the drainage of the power-station property in times of extreme flood, a steam-engine-driven centrifugal pump has been provided in the northeast corner of the boiler-room basement and connected to a large receiving basin into which all of the surface drainage of the property discharges. Under ordinary conditions this basin drains at natural grade through an outflow pipe into the river, the outflow being provided with a tide flap. At times of extreme high water this flap is closed and the centrifugal pump is used for drainage purposes, discharging water into the river against the flood head.

This centrifugal pump is of the sewage type with an open-runner designed to handle trash and débris without stoppage, and the unit is fitted throughout so as to withstand long periods of shutdown and for operation under water if necessary. Between the boiler-room basement and the turbine-room basement are bulkhead watertight doors, so that the boiler-room basement could be flooded

without flooding the turbine room. The busroom is likewise separated from the turbine-room basement so as to render the station practically certain against interruption from accidental flood or breakage of water pipes even under extreme flood conditions.

A general view of the turbine room is shown in Fig. 1. First of all it is large enough to provide room for the units without crowding and for an additional turbine unit. The generating apparatus consists of two 750- and one 500-kw. turbo-generators, all of 80-per cent. power factor and generating three-phase 60-cycle 2,300-volt current at 3,600 r.p.m. The 500-kw. unit, being in good condition, was taken from the old station. These units rest on concrete foundations extending above the floor level. Between the small turbine and the end wall space has been provided for a 1,500-kw. turbo-generator set. The foundation for the 500-kw. machine is large enough to accommodate a 1,500-kw. unit. The building has a capacity of 4,500 kw. The condensing water intake and discharge, the stack and the coal and ash handling can take care of 6,000 kw. electrical output. The electric machinery now installed has a capacity of 2,000 kw.

Three exciter sets are situated between the turbines and the switchboard. Two of them are turbine driven, each having a capacity of 35 kw. and delivering current at 125 volts at 3,600 r.p.m. The other is a motor-generator set of 15 kw. capacity, delivering current at 125 volts at 1,130 r.p.m.

The 25-panel slate switchboard is designed to control the present apparatus and any additional units that may be installed in the future. All lines are carried from the switches through conduits in the roof of the annex on the front of the building. Besides the switching apparatus the board carries a watt-hour meter, a double-curve voltmeter, frequency indicator, power-factor indicator, the regular ammeters, etc.

The electric energy from the main generators is carried to either of two duplicate sets of busbars through oil switches, located in a busroom (Fig. 2) in the basement, and which are operated from the switchboard through a system of rods and bell cranks. The energy is distributed from the busbars to three feeders for general lighting and for motor service, to the rotary converter and to street-lighting apparatus, which is also in the busroom. The latter consists of two mercury arc rectifiers and of four constant-current transformers that formed a part of the old station equipment. All of this apparatus is controlled by oil switches, each switch being provided with a relay to operate in case of overload.

The main turbines are equipped with surface condensers so piped that each unit can be used with the condenser on either side. The circulating water is supplied to each condenser by an 8-in. centrifugal pump directly connected to a 5x5-in. vertical engine running at 300 r.p.m. (Fig. 3). The circulating water is taken from the river and passes through a 36-in. pipe, underneath the building foundation to an intake crib 125 ft. from the river bank. It is discharged into the river through a pipe terminating at the river bank. The condensed steam from the condensers discharges into a concrete hotwell, from which it is taken by either of two 6x6x10-in. duplex pumps and delivered to the heater at one corner of the turbine room.

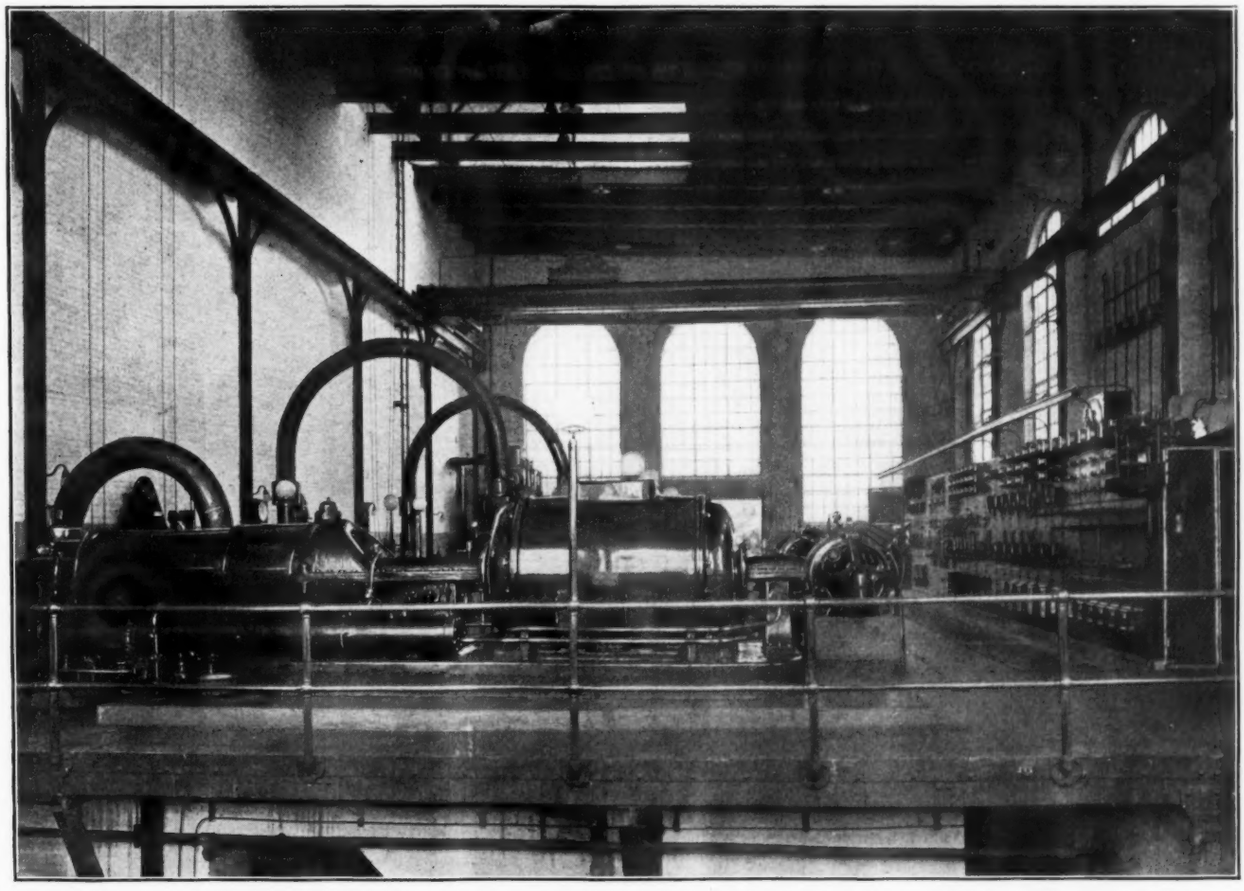


FIG. 1. GENERAL VIEW OF THE TURBINE ROOM OF THE DANVILLE MUNICIPAL LIGHTING PLANT

FIG. 2. OIL SWITCHES AND BUSBARS IN BASEMENT

ranged in two batteries (Fig. 7) and there is room for two more boilers of the same capacity. A steam pressure of 190 lb. is carried, with 150 deg. superheat. The furnaces have stationary grates and are hand-fired. Permanent soot blowers are attached to the boiler setting.

The coal is delivered to the plant on a railroad siding and dumped just outside of the boiler room on a concrete-floored storage space. It is brought into the boiler room in wagons holding about 1,200 lb. each. Each wagonload is weighed on platform scales set in the boiler-room floor, and a record is kept of the amount of coal burned.

The ashpits of the boilers connect with hoppers, from which the ashes are discharged into a small car running on a track in the basement. The loaded car is lifted to the boiler-room floor by an electric elevator and wheeled to the outside of the plant. The furnace gases pass through the uptake to a 190-ft. reinforced-concrete chimney having an inside diameter of 9 ft. at the top and 14 ft. at the bottom. It is lined with brick to a height of 90 ft. The draft is controlled by a damper regulator.

The air and condensate from each condenser is carried forward by a 6x14x10-in. air pump placed below the condenser and turning at 70 r.p.m.

Two 8x5x10-in. boiler-feed pumps are piped to the feed-water heater, and both are automatically controlled. When the condensate is not sufficient, makeup water is admitted to the hotwell through a float-controlled valve, either from the city main or from the river by using one of the service pumps. A meter in the boiler-feed pipe line measures all water going to the boilers, and the volume is recorded by an indicating and recording instrument placed in the turbine room. Fig. 4 is a view of the boiler-feed and service pump.

The boiler equipment consists of four water-tube boilers, each with 3,500 sq.ft. of heating surface. They are ar-

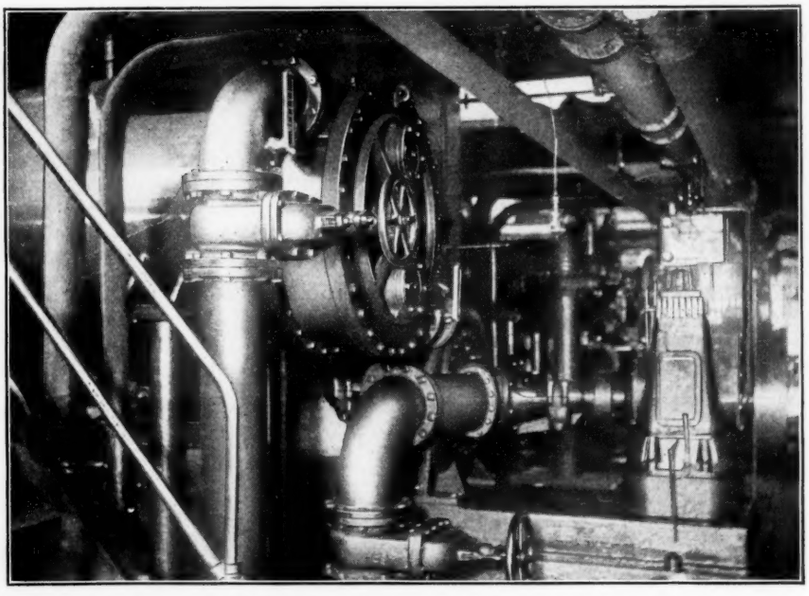


FIG. 3. CONDENSERS AND CIRCULATING APPARATUS

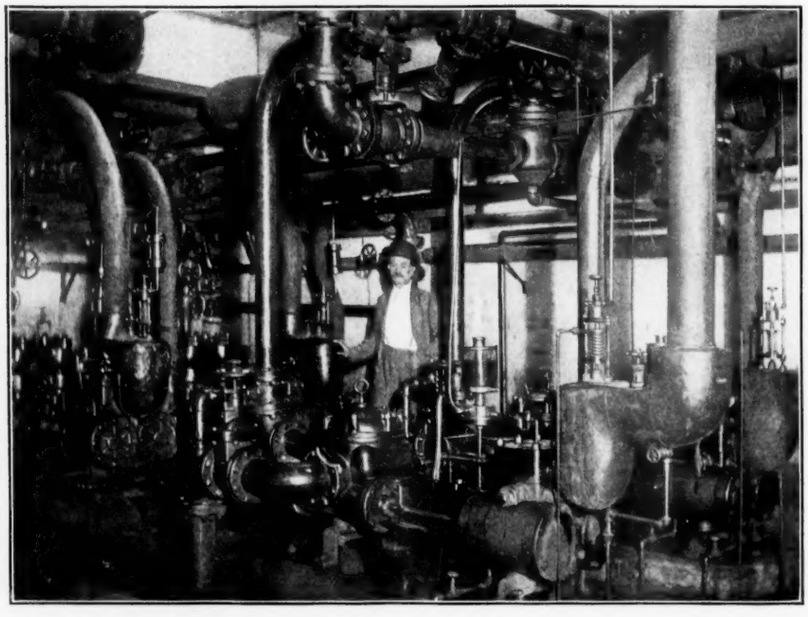


FIG. 4. A VIEW OF THE BOILER-FEED AND SERVICE PUMPS LOCATED AT ONE END OF THE TURBINE-ROOM BASEMENT

Steam from each boiler is conducted from each of the two drums through a 6-in. pipe to a 6-in. long-radius branch line connecting with an 8-in. main that extends along the front to the side of the boiler setting; then, with a long-radius bend, it extends toward the back, dropping to the basement at a point opposite the outlet connections. The two batteries of boilers are not connected until the two 8-in. mains join an 8-in. header in the turbine-room basement. This header runs from one end of the basement to the 500-kw. turbine, where it is blanked at a tee connection ready for extension to a future unit and for connecting with another battery of boilers. A plan of the station indi-

PRINCIPAL EQUIPMENT OF THE DANVILLE, VA., MUNICIPAL ELECTRIC PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
1	Turbo-generator	Horizontal	500-kw.	Main generating unit	3,600 r.p.m., 190 lb. steam, 3-phase, 60 cycle	Allis-Chalmers Mfg. Co.
2	Turbo-generators	Horizontal	750-kw.	Main generating units	3,600 r.p.m., 190 lb. steam, 3-phase, 60 cycle	General Electric Co.
1	Rotary	Direct-current		Motor service	1,200 r.p.m., 550 a.c. volts, 182 amp.	General Electric Co.
2	Turbo-generators	Direct-current	35-kw.	Exciter sets	3,600 r.p.m., 125 volts	General Electric Co.
1	Motor-generator	Direct-current	25-hp., 15-kw.	Exciter set	1,130 r.p.m., 125 volts, motor 220 volts	General Electric Co.
3	Condensers	Surface		With main generators		C. H. Wheeler Mfg. Co.
3	Pumps	Mullen	6x14x10-in.	With condensers	70 r.p.m.	C. H. Wheeler Mfg. Co.
3	Pumps	Centrifugal	8-in.	With condensers	300 r.p.m.	C. H. Wheeler Mfg. Co.
3	Engines	Vertical	5x5-in.	Driving centrifugal pumps	300 r.p.m.	C. H. Wheeler Mfg. Co.
2	Pumps	Duplex	6x6x10-in.	Service	Variable speed	Warren Steam Pump Co.
2	Pumps	Duplex	8x5x10-in.	Boiler feed	Variable speed	Warren Steam Pump Co.
4	Regulators	Pump		On boiler feed and service pumps	Automatic	Schade Valve Co.
1	Meter	Venturi	3-in.	Boiler-feed water	Registering and indicating	Builders Iron Foundry Co.
1	Heater	Open		Heating feed water	Exhaust steam	Harrison Safety Boiler Works
4	Boilers	Water-tube	350-hp.	Main steam generators	190 lb. pressure, 150 deg. superheat	Babcock and Wilcox Co.
1	Chimney	Concrete	190 ft. high, 10-14 ft. dia. inside	Furnace gases	Natural draft	General Concrete Construction Co.
1	Regulator	Damper		Controlling draft	Automatic	Stillman-Carmichael Co.
4	Blowers	Soot		With boilers	Intermittent	Bayer Soot Blower Co.

cating the layout of the piping is shown in Fig. 5. About midway of the header a U-bend is inserted to care for expansion and contraction. A 6-in. branch extends up through the turbine floor and turning with a long-radius bend (Fig. 6), is connected to the turbines. From one end of the main header a 4-in. pipe loops the basement and joins the main header at the opposite end. Movement of this pipe line is taken care of by two U-expansion bends. This pipe feeds the 3-in. branches to the two service pumps and the 4-in. leads to the two exciter turbines.

The two boiler-feed pumps (Fig. 8) are at the end of the basement and are piped through 3-in. long-radius bends to the auxiliary loop header near the point of connection with the main header. The engines driving the circulating pumps and the steam end of the air pumps are piped to the main steam header. Exhaust steam from the various auxiliaries goes through a 6-in. loop header to an open heater. Feed water is taken from the heater through an 8-in. suction pipe and discharges through a 5-in. line with 2½-in. branches to each boiler. A connection is also made with the 4-in. blowoff pipe for feed-

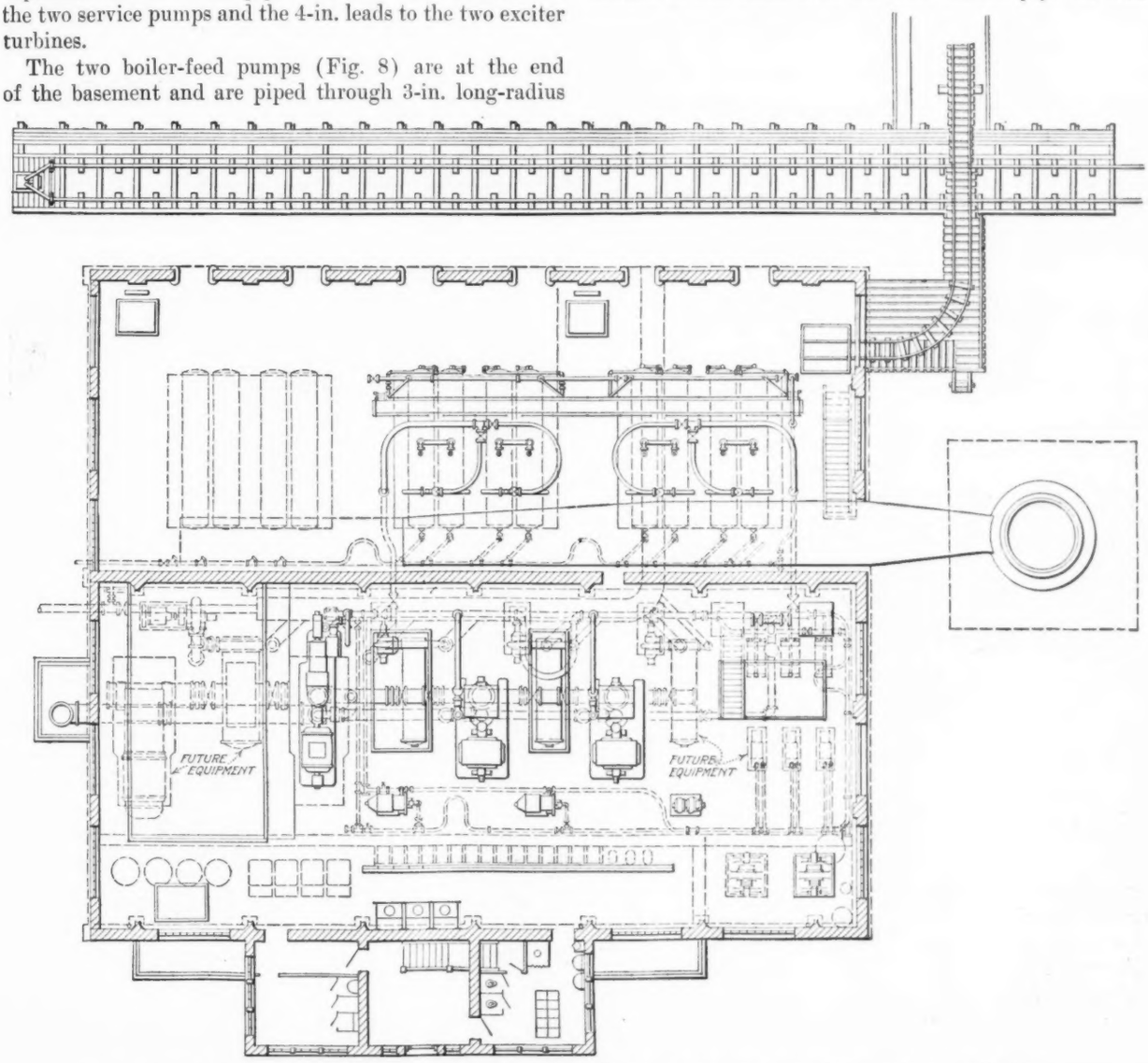


FIG. 5. PLAN OF THE BOILER AND TURBINE ROOMS, SHOWING THE GENERAL PIPING SYSTEM

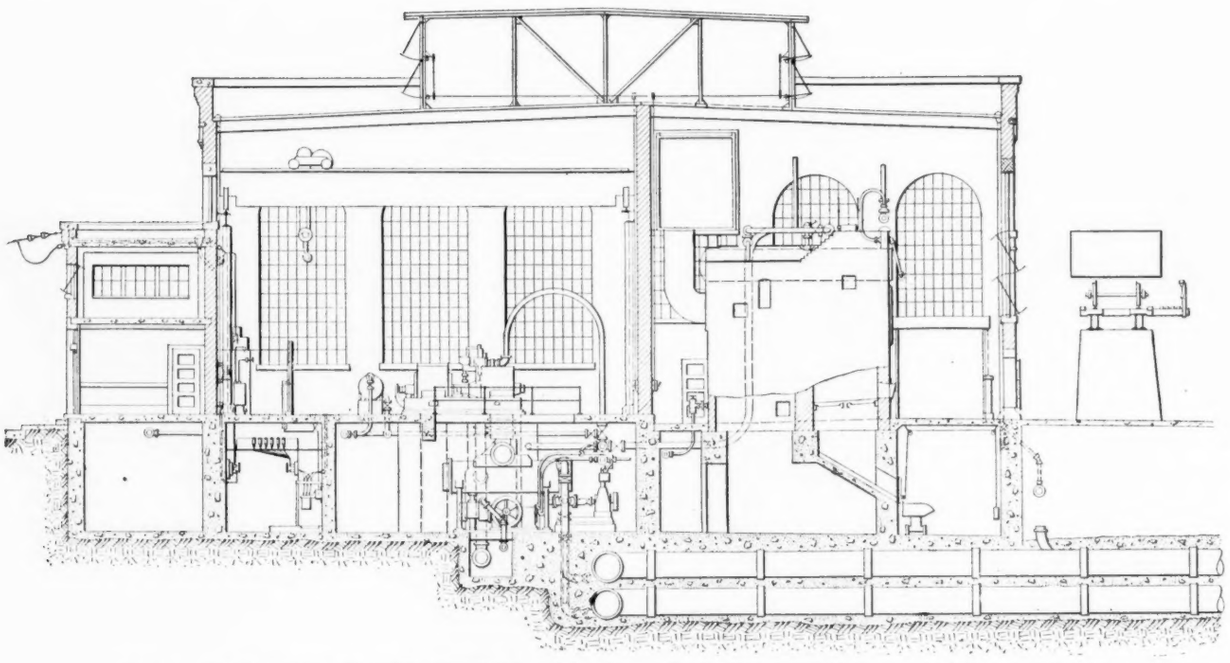


FIG. 6. ELEVATION OF THE TURBINE ROOM AND BASEMENT, SHOWING PRINCIPAL PIPING

COST OF THE NEW ELECTRIC PLANT

Land		$18,110.00
Building and machinery foundations		20,844.97
Building superstructure		29,394.03
Furnaces and Boilers		
Boilers, superheaters, etc.	$27,191.50	
Chimney and extra length of flue	5,589.36	
Coal-charging wagons	130.00	
Scales	90.00	
Damper regulator	55.00	
Ash car	90.00	
Miscellaneous	514.18	
		33,660.04
Accessory Steam Equipment		
Feed-water heater	$1,140.00	
Condensers	11,000.00	
Expansion joints	300.00	
Miscellaneous	179.05	
Pumps	1,301.13	
		13,920.18
Piping		
Valves	$6,418.83	
Piping	13,879.85	
Pipe covering	1,985.00	
Miscellaneous	1,148.09	
		23,431.77
Turbines		
Two turbines and rotary and miscellaneous		25,265.25
Electrical Equipment		
Switchboard	$19,340.33	
Miscellaneous	4,411.46	
		23,751.79
Intake and Discharge Lines		
36-in. intake pipe	$701.80	
Suction and discharge pipes	1,772.75	
Labor	7,931.56	
Miscellaneous	3,732.63	
		14,138.74
Spur track		8,766.89
Miscellaneous Station Equipment		
Oil filters	$170.00	
Cranes	1,700.00	
Air compressor and tank	212.80	
3-in. water-meter tube	16.00	
		2,098.80
Miscellaneous charges		3,078.04
Interest		1,055.57
Bond issue cost		1,229.23
Engineering		10,168.04
Total		$228,913.34

ing through the bottom drum in an emergency. The blowoff main is protected by two U-expansion bends, and fittings are in place ready for connecting to the future boiler units.

Speaking tubes afford communication between the office and turbine-room basement and boiler room and also between the turbine room and the boiler room and basement.

In the basement is a cylindrical oil reclaimer to which the condensate from the auxiliary exhaust steam lines is carried after being trapped. The water automatically separates from the oil by precipitation and evaporation in the reclaimer.

Record is kept of the performance of the plant. The cost table gives the figures of various apparatus connected with the plant, making a total of $228,913.34. The

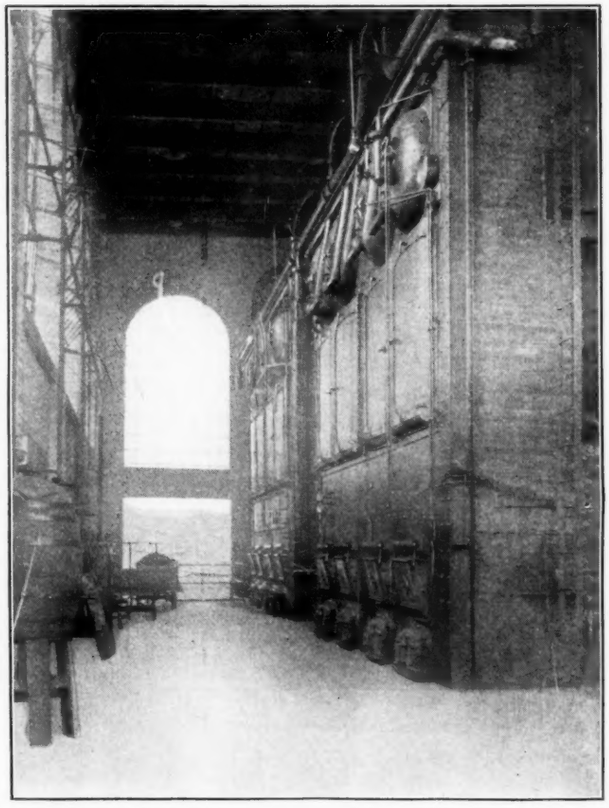


FIG. 7. PARTIAL VIEW OF THE BOILER ROOM

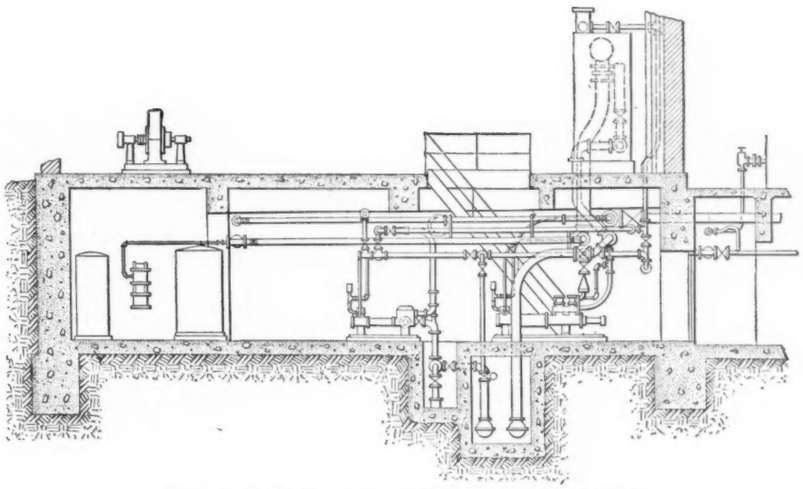


FIG. 8. PIPING OF THE BOILER-FEED PUMPS

receipts from the sale of electric energy for the year ending Apr. 30, 1914, showed an increase over former years, but the income was not so much as the previous year because the rates had been cut from 10 to 25 per cent. as compared with former prices. The total receipts for the year were $79,936.27, and the total disbursements were $53,030.83, showing a profit of $26,905.44 exclusive of depreciation. The present rate of charge for illumination is from 8 to 6c. per kw-hr., less 10 per cent. for prompt payment. Power and sign rates are from 3 to 1c. per kw.-hr., according to the quantity used.

It is expected in the near future to pump the water supply of the city at off-peak hours by power supplied from this station, operating pumps at the main pumping station. It is also intended to operate a supplemental booster pumping station for supplying water service to North Danville, which lies at a higher average elevation than the City of Danville proper, but which is served from the same main pumping station at present. This will effect a material reduction in the total cost of operation of the city's utilities.

The new plant is uptodate in all respects and a credit to the city and the Scofield Engineering Co., of Philadelphia, which did the consulting engineering in connection with the installation.

Visits of Inspector Brown--XV

By J. E. Terman

SYNOPSIS—The Chief tells Brown why autogenous welds are not acceptable in boiler construction and shows that tests of welded specimens do not offer satisfactory conclusions that that method of making a joint is satisfactory or even safe for boiler work.

"Chief," said Brown, as they left the office to inspect some boilers a short way out of the city, "why is it that we will not accept autogenous welds except in certain places on a boiler, while tests made of such welds seem to indicate that they are usually stronger than lap-riveted joints?"

"Well, Brown, you have brought up an important subject, but you know that we never refuse to insure boilers because we are not particularly enthusiastic over some portion of the construction or design. Now we have, or at any rate we believe we have, a good reason to doubt the safety of such welds for general application to boiler repairs or construction, or we would not be taking the stand that we do. What kind of tests do you refer to, Brown, as indicating that autogenous welds for boiler work are as strong as the average lap-riveted seam?"

"Why, I have seen many tests," replied Brown, "some of them having been made by Government officials, where test pieces were cut from the solid plate and also specimens prepared from the same plate by cutting the specimens in two and welding them together. Some of these test results gave the tensile strength of the specimens and also the ductility measurements and elastic limit."

"Now, Brown, such tests as you describe have practically no bearing on the question of the safety of autogenous welds for boiler work or on our company's refusal to consider these welds safe in most instances where they are used for this class of work. In the first place, the skill of the operator is a big factor in determining whether a weld of this kind is properly made or not, just the same as in the case of the usual welds made in the blacksmith's forge before the autogenous method became so common.

"You know, Brown, that it is beyond human possibility, for an inspector or anyone else to examine a weld of any character after it has been made and tell very much about whether it is a good weld or not, and the appearance of an autogenous weld after completion certainly gives no indication as to the possible defects that may exist in it. For these reasons a weld of any kind can never be considered as reliable as a riveted joint for the purpose of joining two pieces of plate, for in the case of the riveted joint uncertainty as to the average strength of the connection rarely exists. However, if autogenous welds could be made so that there was no doubt about their being perfect and it was a certainty that the strength of the weld was at least equal to that of the best riveted joint, their general use in boiler work would still be attended with danger."

"Well," said Brown, "I do not follow you in that statement, for it does seem to me that if the edges of two plates were held together equally strong by two different methods, one of which preserved the true cylindrical form while the other one deformed the shell at the joint, as is the case with practically every form of riveted joint now used, the method retaining the true form of the cylinder would be the best."

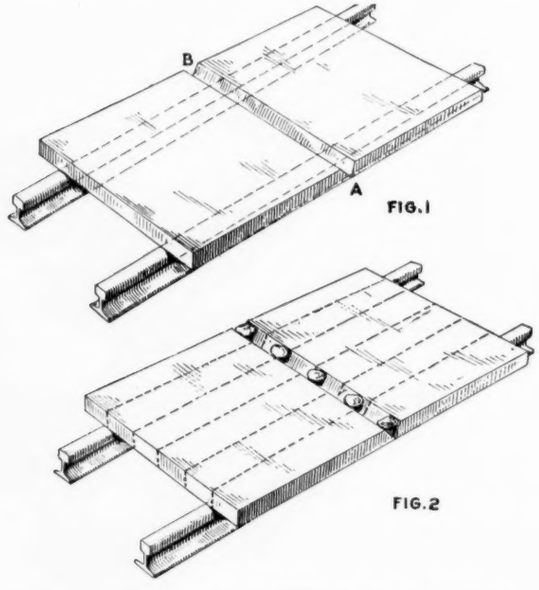
"Your reasoning would be logical, Brown," said the Chief, "if it was only necessary to consider the points you mention, but you have not considered how the making of

these two kinds of joints may have affected the shell. Now all of the tests of autogenous welds that you have seen reported have been made on narrow specimens about the size of the standard test specimen, haven't they?"

"Yes," answered Brown, "I believe they have, but I have never paid much attention to the question of the size of the test specimens."

"Well," continued the Chief, "tests of that kind may give you the average relation between the strength of an autogenous weld and the solid plate that is joined together; but that is not what we are concerned with, because these welds are not made under the same conditions that would obtain in boiler work. I witnessed the testing of some samples of autogenous welds once, the results of which have never been published, and these tests were the kind that tend to show whether autogenous welds are really safe for use in boiler work or not."

The Chief and Brown had reached the station and after seating themselves in the train, the Chief continued his talk: "Instead of the small test specimen that we have been talking about, where the question of internal stresses set up by the welding operation are practically eliminated, pieces of sheet 2½ to 3 ft. square were welded together. An attempt was made to produce these test specimens under the same conditions that would exist in an actual boiler repair, and in order to imitate the rigidity of the surrounding parts, as when an attempt should be made to weld up a crack in a boiler sheet, the pieces of plate that were to form the sample were fastened to pieces of railroad rails like this," said the Chief, drawing Fig. 1. "It was assumed that, while this arrangement did not exactly



FIGS. 1 AND 2. TEST PIECES FOR WELDING
Fig. 1—Test piece on rails. Fig. 2—Test piece spot welded

reproduce boiler conditions, there would be some similarity and that the test of the specimens made under these conditions should show if the rigidity of the parts was a serious factor affecting the strength of welds of a similar character.

"In making some of the first specimens, the weld was started at *A* and continued across the sample to *B*, but it was demonstrated at once that this would not do, because when the side at *B* was reached, the stresses set up in the parts by the act of welding were so severe that the edges of the plate had crawled up on each other and overlapped about half an inch. The next scheme was to weld the specimens together in spots, like this," said the Chief, drawing Fig. 2, "the idea being that the welds at each spot would hold the samples in position so that the general welding of the two pieces could be accomplished in a satisfactory manner. This scheme apparently worked fine, and there was no further trouble in welding the samples, and after the welds were properly made, sample strips for testing were burned off across the weld, like this" (indicating the dotted lines in Fig. 2).

Welds Did Not Hold

"Why did they burn the strips off instead of cutting them off in a planer or milling machine?" asked Brown.

"Well, one reason given, and I believe it to be true, was that any shock to the sample would be avoided by removing it in this manner; another was that it was quicker and easier to burn them off. These samples," continued the Chief, "proved at once that there was little doubt that welds of this character would set up tremendous stresses in the plates joined together, for when some of the strips were burned off, instead of waiting as decent test specimens should have done until they arrived at the testing machine, they broke in two when they were separated from the balance of the plate, without having any external stress applied. An attempt to weld up a crack in a plate of a boiler, will no doubt set up the same kind of internal stresses in the surrounding parts as in the case of these test specimens, and there is no way of telling just when they are ready to let go. Of course, if the parts are so arranged that they may be free to expand and contract, this difficulty may be avoided, but it will be only in rare instances that sufficient freedom will be provided.

"Any other form of local heating is likely to produce severe internal stresses in a boiler plate, and unless the material is being worked or is free to expand or contract, local heating of the parts should not be attempted," said the Chief. "I saw a good illustration of this in O'Brien's shop a few days ago. The flanger was getting ready to flange a spot on the surface of a rather thick drum of small diameter. The shell of the drum was in the flange fire and had been heated to a point where it was about ready to be worked on, when the whistle blew for noon. You know, Brown, that a blast of the quitting whistle at O'Brien's acts on the men about like an electric shock of 2,000 volts; they drop everything and run. Well, that's what happened this time; every fellow quit, and the flanger rolled the shell out of the fire to keep the sheet from being burned.

"I was somewhat curious about the work that was being done and stopped to examine the cylinder. After it began to cool, I noticed that the place that had been heated was depressed, and I walked over to where the flange foreman was eating his dinner and asked him why the cylinder was depressed at that point as if it had been hit a blow. The flanger told me that no blow had been struck and that those cylinders always sunk in after being heated, if the flanging operations were not completed. I was incredulous about this statement and got the foreman to heat up another cylinder after the dinner hour, so that I could watch the operation and be sure that no

external force was applied, but the result was the same as before.

"The effect that I noticed was about like this," said the Chief, making a sketch like Fig. 3. "Of course, I have exaggerated the depression a little in drawing it, but it was very noticeable. The cylinder was about 24 in.

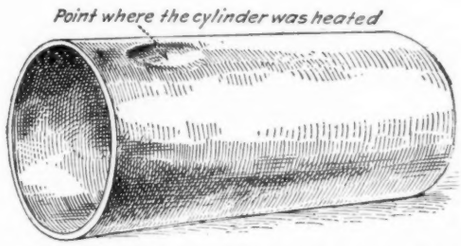


FIG. 3. DEPRESSION OF CYLINDER AFTER HEATING

in diameter and the heated spot about 8 in. in diameter, and the surface of the cylinder at the center of the heated spot was pulled down out of line fully $\frac{3}{16}$ to $\frac{1}{4}$ in. I was at first at a loss to account for this action, but a little reflection on the subject made the reason clear.

"The cylinder being small and rigid, $\frac{7}{16}$ in. thick, possessed great strength to resist deformation, so that when the spot was heated up for flanging, the tendency of the metal to expand was not accommodated and the metal in the heated spot upset, and when the cylinder cooled off the upset metal placed a tremendous internal tensile stress in the heated part and the immediately surrounding sections, which was great enough to pull the cylinder out of shape as I have indicated. It is easy to see what kind of stresses may be set up in making autogenous welds in the plates of a boiler, where the movement due to the expansion of the parts cannot be taken care of."

"Well, I understand, Chief," said Brown, "that our objection is not on account of the lack of strength in autogenous welds, but on account of the stresses that may be set up in the act of welding."

"Don't go so fast, Brown," replied the Chief, "you are attempting to put words into my mouth. I did not say that we were perfectly satisfied with the strength of such welds, for there are many things that tend to make their strength uncertain. If the oxyacetylene flame is used for the purpose of making welds and the mixture of the two gases in the flame is not just right, the metal in the weld may be injured or it may be burned by overheating. Oxide scale may be formed in the weld as a result of the operator's failure to float up the metal from the bottom, which will prevent a good bond between the parts, and many other things may happen to destroy the strength at the joined section.

"No, Brown, we are not satisfied with the strength of such welds, but even if all the difficulties that tend to make their strength uncertain could be eliminated, there would still be the apparently insurmountable one of getting rid of the stresses set up in welding. We are by no means alone in our distrust of this character of welding because practically all who have had much experience with this method are of about the same opinion."

"Well, Chief, the next time I have to turn down a fellow who proposes to use this method in making a repair, I will be able to do it without leaving him under the impression that I am opposed to it merely because 'autogenous' is a hard word to spell and I want to avoid having to mention it in my report."

Action of Furnace Gases

By S. H. Viall

SYNOPSIS—The hydrocarbons in coal pass from a solid to a liquid state and then into a gas. The action of these gases in a hand-fired furnace and the importance of mixing them thoroughly with air are explained.

When burning coal to produce steam, high CO_2 with no CO is almost universally accepted as positive indication of high furnace efficiency. When using high-volatile free-burning coal, this is not always true. In some cases it is possible to get better returns from the fuel with a comparatively low CO_2.

Most furnaces in use today were designed or were copied from what was considered good practice before much of the information now available relative to burning high-volatile free-burning coal at high capacity had been developed. Many of these furnaces will not give the best returns when the CO_2 exceeds 11 to 12 per cent. at the end of the flame travel. The reasons are insufficient combustion chamber and lack of thorough mixing, at an igniting temperature, of the distillates with the air.

The phrase, "end of the flame travel," as used in this article means as close to the flame as an iron sampling pipe can be placed without burning—usually 2 to 4 ft. beyond the end of the longest visible flame.

Assume, for simplicity of illustration, that all air entering a coal-burning furnace passes in vertical paths through the grates and fuel bed and that the volatile distillates also take a vertical course on leaving the coal. Further, that the air and fuel gas continue to travel for an indefinite distance in exact perpendicular paths. With these conditions there would be above the fire numerous vertical columns of air and combustible gas. Where the strata of air and combustible gas touched one another, a little of the oxygen of the air would unite with some of the coal gas, forming an inert mixture which would continue to travel vertically with the general mass. The zone of combustion would be narrow, as the inert gas will insulate or hold apart the various strata of air and unburned hydrocarbons. If this stratification should continue until the gases reach a temperature below their point of ignition, only a small part of the heat in the hydrocarbon gases is developed. The gases will continue to travel in this stratified condition until some outside influence breaks up the parallel relation of their paths. Merely pouring a bucket of black paint and a bucket of white paint into a vessel large enough to contain them will not result in a mixture of an even gray color. Much mixing and stirring are required, or in other words, the direction of travel of the paints are changed sharply so that they will twist and tumble and mix uniformly.

Similarly the gases from the coal must be thoroughly mixed with the air supply to obtain complete combustion.

The time required for the gases to travel from the fuel bed of a boiler furnace to a region where the temperature is below the ignition point is from $\frac{1}{10}$ to $\frac{1}{5}$ of a second. Considering the quantities of gas passing through the combustion chamber, one can then understand the prime importance of some means of quickly producing this mixture.

Due to the innumerable shapes of the pieces of coal making up the fuel bed and the positions in which they happen to lie, tortuous passages are formed through which much of the air entering the furnace must travel. The outlets of these passages point in varied directions and still other directions may be obtained by deflection from the walls of the passages. Because the multitude of separate streams of air and combustible gases are traveling in every possible direction as they enter the furnace space above the fuel bed, it is evident that they will impinge upon one another and mix to a certain degree.

Although the general mass of gas may be traveling in a vertical direction, there are within that mass many cross-currents and eddies. The farther the main body of gas travels from the fire the less active are the eddies within the mass, unless there is a turn in the line of travel. If a turn does occur, new whirls and cross-currents will be set up, and since the gases are of various specific weights and the several strata are moving at slightly different velocities, the mixing effect of a turn in the general path of the gases is considerable.

Causes of Scrubbing Action

The resistance of the fuel bed to the flow of air through it is not the same at all points, nor is the temperature of the fuel bed uniform. As a result some streams of gas travel at higher velocities than others and, where they adjoin, set up a scrubbing action that helps in the mixing. Burning a given part of the fuel gas suddenly increases its volume, owing to the rise in temperature, and results in further mixing.

Some of the volatile matter may be distilled below the surface of the fuel bed and become thoroughly mixed with the oxygen of the air as it buffets from piece to piece of the coal in its travel to the surface. There is also the scrubbing action as the gases pass along the furnace walls and the influence of counter-currents of air entering through the fire or inspection doors or at other places. All these factors influence the mixing of the general mass of furnace gases.

In return-tubular boilers and horizontally baffled water-tube boilers the general mass of furnace gases makes one or more right-angled turns before reaching a zone below the ignition temperature. Such turns help produce the mixture desired, and the sharper the turn and the higher the velocity of the gases the more thorough the mixing.

Distillation of the volatile matter begins as soon as the coal is thrown into the furnace, and the hotter the furnace the more rapid the distillation. The volatile matter in the coal is not instantly changed into a gas. As a matter of fact the material passes from the solid to the liquid state and, upon further heating, to a gas. The process followed is the same as that through which water passes in changing from ice to steam.

Upon being placed in a furnace, a piece of ice would melt and the liquid formed would spread out upon the surrounding surface. Consider the furnace temperature to be a few hundred degrees above the boiling point of water. Steam would then form rapidly upon the surface of the water. Other liquid from the melting ice would tend to flow over the forming steam, the expansion of which would blow the liquid away, breaking it up into small pieces. Expansion of the steam formed on the lower side of the sheet of liquid would soon break it into small pieces. As the pieces are thrown around by the forming steam, they would strike one another and be still further divided. The heat would cause steam to form upon the surface of these small globules. In a brief interval the ice would be surrounded by a fog or mist made up of minute particles of water in the shape of balls. The cores of these tiny spheres might be at the temperature of the melting ice. On the surface steam would be forming. The condition of this steam and water vapor would be similar to that existing above a pile of hot ashes and clinker immediately after it had been sprinkled with water.

Mechanism of Volatilization

The time required for the small spheres of cold water to evaporate depends mostly upon the heat transferred by convection and upon the rapidity with which the encircling blankets of steam are carried away and replaced by more highly heated material. Radiant heat has but little direct effect upon the liquid spheres because it is absorbed by the surrounding steam.

The approximate range of the boiling temperatures of most of the various volatile constituents of the coal is from 300 to 900 deg. F. The lightest oils boil at 300 deg. or less, while some of the heaviest must be heated to above 900 deg. The temperatures at which the gases from these distillates will ignite and burn are considerably higher than their boiling points.

The hydrocarbons in coal are passed into the furnace in the solid state. Furnace temperatures, usually ranging from 1,800 to 3,000 deg. F., cause the volatile oils to be driven out of the coal and broken up into a fog or mist similar to the action described for the water.

As it first leaves the fuel bed, the flame accompanying the burning of bituminous coal is usually a fog of minute spheres of oil boiling on their surfaces, the gas thus formed uniting with oxygen when possible. If the particles of oil reach a region below their ignition temperature, they may gasify but will not burn.

Advantages of Scrubbing Action

In some furnaces where the distillates are driven off in slugs, which is usual with hand firing, it will be a benefit to cause the whole body of furnace gases to travel a path corresponding to that of steam in passing through a separator. Much of the liquid oil will be impinged upon the brickwork or other baffling medium and retained until gasified. In passing through the "separator" the furnace gases are more or less mixed by the twisting and tumbling due to turns in the path of travel. The internal friction and scrubbing action throughout the gas assists in gasifying the spheres of oil and bringing this gas in contact with oxygen.

It is simple to get enough oxygen into a furnace to completely burn all the distillates. No difficulty is encountered until the air supply is reduced to a point at which 10 per cent. CO_2 at the end of the flame travel

will be obtained. In specific instances slight loss due to unburned hydrocarbons may begin to appear at this point. Losses of this character are common in furnaces burning high-volatile free-burning coal when the CO_2 reaches 12 to 14 per cent. at the end of the flame travel.

No positive statement can be made as to the most efficient percentage of CO_2 to carry. The character of the coal, the shape of the furnace, the manner of feeding the coal, the rate of burning, the draft intensity, methods of operation and other variable factors—all these influence the results. The only way to determine the most efficient percentage of CO_2 to carry in a given case is by experiment. Operate the unit at a given capacity with, say, 13 per cent. CO_2 at the end of the flame, and determine the efficiency. Repeat with a higher or lower percentage of CO_2. Compare the efficiencies obtained for the different tests. Make comparative tests for other points of capacity. Curves plotted between capacity and CO_2 and efficiency and CO_2 will show the range within which the CO_2 should be kept. The curves will also show whether it is of advantage to increase or decrease the percentage of CO_2 with a given change in load.

Highest CO_2 Not Always Best

The writer knows of a stoker-fired plant containing 400-hp. boilers in which the CO_2 at the dampers averaged 9½ per cent. with no CO. Investigation showed about 13½ per cent. CO_2 at the end of the flame travel. The boiler settings were worked upon until 13 per cent. Co_2 was obtained at the dampers with the same furnace conditions. The efficiency was not yet satisfactory. Experimental tests were then made which showed that 10½ to 11 per cent. CO_2 gave the best returns. Low-grade Iowa coal was used. The efficiency was about 65 per cent. and was between 3 and 4 points higher than previously obtained with 13 per cent. CO_2 and no CO.

The common burner of the domestic gas stove and the bunsen burner are examples of the advantage of the thorough mixture of combustible gases and air. With properly adjusted burners, the housewife sets a kettle of cold water directly in the flame without arresting the burning of the combustibles. A bunsen burner with air blast will handle gas through a comparatively wide range in the rates of burning with but small difference in the length of flame. If gas be burned from the open end of a plain pipe at a rate corresponding to either of the burners mentioned, the flame produced will be much longer and of a dull yellow color with trails of smoke traveling away from it.

The usual fuel bed of bituminous coal corresponds in a rough way to a group of small open-end gas pipes discharging into the space above the fire. Increasing the quantity of gas will increase the length of the flame. Increasing the efficiency of mixing the gas and air will shorten the flames.

Bituminous coal is burned at higher rates per square foot of grate per hour than formerly, yet but little has been done to increase the efficiency of mixing the air and distillates. The chief attempt toward effecting a good mixture has been the adoption of large combustion chambers which provide for comparatively long flame travel. This allows more time for the minor forces to cause mixture after the stronger eddies and whirls have died out. The minor forces are the scrubbing action between strata moving at different velocities and the interference with the gas travel by the sudden expansion of particles of gas due to combustion.

With underfeed stokers, distillation commences as the fresh coal approaches the 300-deg. region and continues as the coal moves toward the surface of the fire. Usually the distillation is completed while the coal is yet a few inches below the top of the fire. The air supply and the volatile distillates must work their way up through passages having many turns and twists. At each turn both the air and distillates are impinged against pieces of coal. This action precipitates the oily liquids upon the coal and mixes the combustible gases with the air. The temperature of this material is raised as it approaches the surface of the fire. The lighter gases ignite first and then the heavier ones.

This thorough mixing of the distillates and the air is one of the principal reasons why the underfeed stoker will handle wide variations in load with an efficiency curve approaching a flat line. At high rates of burning the method of mixing the great quantities of gases produced is as important as having the quantity of air under mechanical control.

The action of the hydrocarbons of the coal during distillation, the mixing with air and their combustion, as outlined, offer an explanation for many phenomena in furnace operation. The reasons for the success or failure of devices or methods used for smoke abatement can be readily determined in the same way. The causes of gas explosions in boiler furnaces can be understood also when one is thoroughly acquainted with the action of these hydrocarbon distillates.

Much has been written about the four basic requirements for combustion. It has often been stated that for complete combustion such as is required for smokeless operation there must be sufficient air, adequate temperatures, proper mixture of air and fuel, and room for expansion of the gases of combustion. It is easy to obtain the air, the temperature and the room. To get better results, more attention must be given to obtaining intimate mixtures. The volatile matter of soft coal ordinarily runs from 15 to 35 per cent. and represents 20 to 45 per cent. of the heat in the coal. The importance of burning it as completely as possible and not allowing the greater percentage to escape unburned up the stack should be realized.

Condensation in Pipe Line

Condensation to be allowed for in pounds of water in a given pipe line depends on two things—the latent heat of the steam at the given pressure and the escape of heat from the pipe (usually expressed in B.t.u. per hour per square foot of surface per degree difference in temperature) multiplied by the total square-foot surface and temperature difference. The condensation per hour therefore is found by dividing the total heat loss per hour by the latent heat of the steam.

Example: In 100 ft. of 7-in. pipe carrying steam at 175 lb. abs., having a temperature of 370.8 deg. F. and exposed to an external temperature of 70 deg. F., the condensation per hour from bare pipe taken at the rate of loss commonly used—that is, 3 B.t.u. per sq.ft. per deg. difference in temperature—would be: 100 ft. at 2 sq.ft. per lin.ft. (for 7-in. pipe) = 200 sq.ft. (370.8 — 70 = 300.8 deg.) × 3 = 180,480 B.t.u. per hr. ÷ 854.7 (latent heat in the steam at pressure given) = 211 lb. condensation per hour.

The saving by the use of heat-insulating coverings is shown by taking the lower rate of heat loss credited to their use, in tables frequently published, using the same data except the rate of heat loss taken at, say 0.4 B.t.u.

$$200 \times 300.8 \times 0.4 \div 854.7 = 29.3 \text{ lb. per hr.}$$

or less than 1/7 the loss when pipe is covered.

A. S. M. E. Code and Massachusetts Rules: A Comparison--II

By Stanley P. Stewart

[The first part of this article by Mr. Stewart appeared in last week's issue.—Editor.]

Provision is made in the Code to determine the lowest allowable tensile strength of a stay having both welded and unwelded portions. Such is not provided for in the Rules. Tables and examples are given in the appendix to ascertain the net cross-sectional area of stay-bolts with V-threads. The method and arrangement of the tables are the same as in the Rules, the difference being only in the stipulated allowable stresses calculated.

Paragraphs 221 and 222 give methods of determining the area required in a diagonal stay in excess of that required for a direct stay as given in Table 4, paragraph 220.

Paragraph 223, "Diameter of Pins and Area of Rivets in Brace," gives requirements not provided for in the Rules as follows:

> The sectional area of pins to resist double shear and bending when secured in crowfoot, sling and similar stays shall be at least equal to three-fourths of the required cross-sectional area of the brace. The combined cross-section of the eye at the sides of the pin shall be at least 25 per cent. greater than the required cross-sectional area of the brace.
>
> The cross-sectional area of the rivets attaching a brace to the shell or head shall be not less than 1¼ times the required sectional area of the brace. Each branch of a crowfoot shall be designed to carry two-thirds of the total load on the brace. The net sectional areas through the sides of the crowfeet, tee-irons or similar fastenings at the rivet holes shall be at least equal to the required rivet section. All rivet holes shall be drilled and burrs removed, and the pins shall be made a neat fit.

Paragraph 224 specifies requirements for the cross-sectional areas of gusset stays. Such stays are not mentioned in the Rules.

Paragraphs 225 and 227, also Table 5, treat the subject of staying the upper segments of tube heads by steel angles in boilers 36 in. and less in diameter and give more complete data and specifications regarding the placing of angles and rivets than do the Rules. The formulas from which these results may be obtained are not stated, but are in the Rules.

Paragraphs 230 to 236 give requirements not found in the Rules; these are: Paragraph 230, Crown Bar and Girder Stays; Paragraph 231, Maximum Allowable Working Pressure on Truncated Cones; Paragraphs 232 and 233, Stay Tubes; Paragraphs 234-6, Tube Sheets of Combustion Chambers.

In Paragraph 237, the height of furnace for a vertical fire-tube boiler is defined the same as in the Rules, but it is not designated that the stay-bolt pitch shall be measured at the furnace sheet nor that the vertical pitch of stay-bolts, measured from the rivets in the lower tube sheet to the first row of stay-bolts, shall not be greater than the maximum allowable pitch of stay-bolts, both of which are designated in the Rules.

Paragraphs 239 to 244 give rules and examples for the allowable working pressure of unstayed plain circular furnaces, circular flues, the Adamson type of flue and corrugated furnaces, which are not found in the Rules.

Paragraph 245 is like the Rules relative to the pressure allowed on a water-tube boiler the tubes of which are secured to cast iron headers—it shall not exceed 160 lb. per sq.in.; but unlike the Rules, there are prescribed limitations of form and size, with specifications for chemical and physical properties and tests. A cast-iron header when tested to destruction shall withstand a hydrostatic pressure of at least 1,200 lb. per sq.in., which is equivalent to a factor of safety of 7.5. It is also required to give a hydrostatic test at 400 lb. per sq.in. gage pressure to all new headers with tubes attached.

Paragraphs 248 to 252 for tube requirements are practically identical with the Rules. In the Code is found a provision not in the Rules, allowing a fire-tube boiler to have the tubes welded at the firebox or combustion-chamber end. The Rules specify that separately fired superheaters shall have the ends of the tubes protected by refractory material where they connect with drums or headers, a specification not found in the A. S. M. E. Boiler Code.

Paragraph 254 requires that plates and butt straps shall be separated and the burrs removed after drilling rivet holes, a requirement not found in the Rules. Paragraphs 258 to 262 for manhole specifications embrace the following differences: In the Code a 10x16 manhole is allowed. Formulas are given for the proportions of manhole frames and reinforcing rings, where it is only specified in the Rules that a manhole frame shall have a net cross-sectional area, on a line parallel to the axis of the shell, not less than the cross-sectional area of shell plate removed on the same line.

There is a slight difference in the specifications for manhole gasket bearing surface. Paragraph 263 states:

> The minimum width of bearing surface for a gasket on a manhole opening shall be ½ in. No gasket for use on a manhole or handhole of any boiler shall have a thickness greater than ¼ in.

The Rules state:

> There shall not be less than ⅛ in. bearing surface for manhole gasket.

Manholes and Handholes

Paragraph 264 covers a difference very important to the manufacturers and users of fire-tube boilers in Massachusetts. It is as follows:

> A manhole shall be located in the front head, below the tubes, of a horizontal return-tubular boiler 48 in. or over in diameter. Smaller boilers shall have either a manhole or a handhole below the tubes. There shall be a manhole in the upper part of the shell or head of a fire-tube boiler over 40 in. in diameter, except a vertical fire-tube boiler, or except on internally fired boilers not over 48 in. diameter. The manhole may be placed in the head of the dome. Smaller boilers shall have either a manhole or a handhole above the tubes.

The Rules state:

> A manhole shall be located in the front head, below the tubes, of a horizontal return-tubular boiler 60 in. or over in diameter.
>
> A manhole or handhole shall be located in the front head, below the tubes, of a horizontal return-tubular boiler less than 60 in. in diameter.
>
> A handhole shall be located in the rear head of a horizontal return-tubular boiler, below the tubes, except one which has a manhole in the front head, below the tubes.
>
> There shall be a manhole in the upper part of the shell or head of a fire-tube boiler over 40 in. in diameter, except a vertical fire-tube boiler.

Paragraphs 265 and 267 regarding washout holes have similar requirements to those of the Rules, differing mostly on those concerning vertical boilers and hence will be given in full:

A vertical fire-tube boiler, except the boiler of a steam fire engine, shall have not less than seven handholes, located as follows: Three in the shell at or about the line of the crown-sheet; one in the shell at or about the line of the fusible plug when used; three in the shell at the lower part of the water-leg. A vertical fire-tube boiler, submerged-tube type, shall have two or more handholes in the shell, in line with the upper tube sheet.

The Rules read as follows:

A vertical fire-tube boiler, except the boiler of a steam fire engine, shall have not less than seven handholes located as follows: Two in the shell, at or about the line of the crown-sheet, and equally spaced; one in the shell, at or about the line of the fusible plug, except a vertical fire-tube boiler having a manhole in the shell or head, through which the fusible plug is accessible; two in the shell, at the lower part of the water-leg, and equally spaced; two located at or about the water-line of the boiler, and equally spaced except a vertical fire-tube boiler having a manhole.

There shall be not less than 1 in. of solid plate in the clear, inside and out, around a handhole opening in a boiler; except that on a stay-bolted surface $\frac{7}{16}$ in. thick or over there shall be not less than ½ in. of solid plate in the clear, inside and out, around a handhole opening.

The requirements in Paragraph 268 for threaded openings are substantially the same as in the Rules. An irrelevant statement that a steam main or safety-valve opening may be fitted with either a steel cast, wrought-steel or bronze-composition nozzle was recently eliminated by amendment from this corresponding section of the Rules.

Safety Valve Requirements

Paragraphs 269 to 290 and the appendix (Code) dealing with safety valves give a radically different treatment from that found in any other rules, which is accounted for by the conference of safety-valve manufacturers, who agreed on the maximum and minimum lifts to be used and the relieving capacity at such lifts. They agreed to stamp all valves with their name or identifying trade-mark, the nominal diameter with the words "Bevel Seat" or "Flat Seat," the steam pressure at which they are set to blow, the lift of the valve disk from its seat and the weight of the steam discharged in pounds per hour at the pressure for which it is set to blow.

The size of valve required is determined on a basis of 6 lb. of steam per hour per square foot of heating surface for water-tube boilers and 5 lb. for all other types of power boilers, and upon the relieving capacity marked on the valves by the manufacturer, provided it does not exceed the maximum allowed in Table 8 of the Code, in which case the size of the valve or valves shall be determined from that table on a basis of the relieving capacity permitted for the stated conditions.

Other important differences, additions or omissions from the Rules are as follows:

Each boiler shall have two or more safety valves, except where a 3-in. or smaller is sufficient. Valves shall be from 1 in. to 4½ in. (The maximum size allowed in the Rules is 5 in.)

The safety-valve capacity must be such that the pressure will not be allowed to rise more than 6 per cent. above the highest pressure to which any valve is set. If this provision is not complied with, additional capacity must be provided. At least one valve shall be set at or below the maximum allowable working pressure and the others may be set within a range of 3 per cent. above the maximum allowable working pressure, but the total range of setting shall not exceed 10 per cent. of the highest pressure to which any valve is set. Each valve shall stand in an upright position when possible. Requirements are given for mufflers when used. Specifications are given regarding vertical lift, chattering, closing pressure after blowing, lifting device, set and range of springs and provision for the guarantee of these by stamping "A. S. M. E. Std." by the manufacturer.

Safety valves over 3 in. and for pressures exceeding 15 lb. shall have flanged inlet connections.

Safety valves on superheaters discharging superheated steam are required to have the seat and disk of nickel composition or equivalent material and the spring fully exposed outside of the valve casing and protected from contact with the escaping steam.

No specific provision is made, as is in the Rules for two or more boilers that are allowed different pressures but are connected to a common steam main.

In Paragraph 291, Water and Steam Gages, the requirements are similar to the Rules. Differences are as follows:

Code—Each boiler shall have at least one water-glass, the lowest visible part of which shall be not less than 2 in. above the lowest permissible water level.

Rules—Each boiler shall have at least one water-glass, the lowest visible part of which shall be above the fusible plug and lowest safe water line.

Code—Each boiler shall have three or more gage-cocks, located within the range of the visible length of the water-glass, except when such boiler has two water-glasses with independent connections to the boiler and located on the same horizontal line and not less than 2 ft. apart.

Rules—Each boiler shall have two or more gage-cocks, the center of which shall be located vertically within the range of the visible length of water-glass, when the maximum pressure allowed does not exceed 15 lb. per sq.in., except when such boiler has two water-glasses, located not less than 3 ft. apart, on the same horizontal line.

Each boiler shall have three or more gage-cocks, the center of which shall be located vertically within the range of the visible length of water-glass, when the maximum pressure allowed exceeds 15 lb. per sq.in., except when such boiler has two water-glasses located not less than 3 ft. apart, on the same horizontal line.

Paragraphs 296 and 298 regarding steam gages are the same as the Rules with the exception that, according to the Code, connections to gages may be of copper or bronze composition as well as brass.

Paragraph 299 specifies that all fittings shall conform to the American standards as given in the appendix, standard fittings up to 125 lb. and extra-heavy fittings for pressures exceeding 125 lb. working pressure. The Rules state that the fittings from the boiler up to the valves shall be extra heavy, made to the manufacturers standard for high pressure. A formula is also given in the Rules for the minimum thickness of cast-iron nozzles.

Paragraph 300, Code, says that a boiler superheater connection need not have a stop valve. Exception is made only to a safety-valve connection in the Rules.

Paragraph 302 requires that extra-heavy main stop valves be used when the maximum allowable working pressure exceeds 125 lb. per sq.in. The Rules require extra-heavy valves when the pressure allowed exceeds 100 lb. Paragraph 303, relative to these valve requirements is as follows:

When two or more boilers are connected to a common steam main, two stop valves, with an ample free blow drain between them, shall be placed in the steam connection between each boiler and the steam main. The discharge of this drain valve must be visible to the operator while manipulating the valve. The stop valves shall consist preferably of one automatic nonreturn valve (set next the boiler) and a second valve of the outside screw and yoke type; or two valves of the outside screw and yoke type may be used.

The Rules state:

Two stop valves of the outside screw and yoke type, with an ample valved drain between them, having an open discharge, shall be placed on the main steam pipe of a boiler set in battery, when the pressure allowed on any boiler in the battery exceeds 15 lb.

Paragraph 307 requires that the surface blowoff pipe shall be carried through the shell or head with a brass

or steel boiler bushing. The Rules allow the opening to be reinforced.

Paragraph 310 states:

The blowoff pipe or pipes shall be extra-heavy from boiler to valve or valves, and shall run full size without reducers or bushings. All fittings between the boiler and valves shall be of steel.

The Rules state:

When the pressure allowed on a boiler exceeds 15 lb. per sq.in., the bottom blowoff pipe and fittings, from the boiler to the valve or valves, shall be extra heavy.

Paragraph 311 requires that:

When the maximum allowable working pressure exceeds 125 lb. per sq.in., the bottom blowoff pipe shall have two valves or a valve and a cock and such valves or valve and cock shall be extra-heavy, except that on a boiler having multiple blowoff pipes, a single master valve may be placed on the common blowoff pipe from the boiler, in which case only one valve on each individual blowoff is required.

The corresponding requirement of the Rules states:

When the pressure allowed on a boiler exceeds 100 lb. per sq.in., the bottom blowoff pipe shall have two valves or a valve and a cock; and such valves or valve and cock shall be extra-heavy.

Paragraph 315, under Feed Piping, says:

The feed water shall discharge at about three-fifths the length of a horizontal return-tubular boiler from the front head (except a horizontal return-tubular boiler equipped with an auxiliary feed-water heating and circulating device), above the central row of tubes, when the diameter of the boiler exceeds 36 in. The feed pipe shall be carried through the head or shell near the front end with a brass or steel boiler bushing and securely fastened inside the shell above the tubes.

The Rules do not except a boiler equipped with an auxiliary feed-water heating and circulating device. There is no provision in the Code for feed pipes on boilers less than 36 in. diameter, having a pressure greater than 15 lb. per sq.in. There is opportunity for misunderstanding because of the unnecessary statement, in Paragraph 268, that a feed-pipe connection may be fitted with a brass or steel boiler bushing.

Paragraph 318 states that when a pump, inspirator or injector is required to supply feed water to a boiler plant of over 50 hp., more than one such appliance shall be provided. There is nothing in the Code to define a horsepower.

Paragraph 319 requires valves of the straightway type on boilers fitted with a Lamprey mouthpiece; the type of valve is not mentioned in the Rules.

Paragraphs 320 and 321 are similiar to the Rules, but are enough different to warrant complete comparison. The Code states:

The minimum size of pipes connecting the water column to a boiler shall be 1 in. Water-glass fittings or gage-cocks may be connected direct to the boiler.

The water connections to the water column of a boiler shall be of brass and shall be provided with a cross to facilitate cleaning. Either the water column or this connection shall be fitted with a drain cock or drain valve with a suitable connection to the ashpit or other safe point of waste. The water column blowoff pipe shall be at least ¾ in.

The Rules state:

The minimum size of pipes connecting the water column of a boiler shall be 1 in.

The water connection to the water column of a boiler shall be of brass when the allowable pressure exceeds 15 lb. per sq.in.

On each water connection to a water column where there is a right-angled turn, there shall be located at least one gate valve and pipe of a diameter not less than ½ in., for the purpose of blowing out said water pipe. This shall not apply to a right-angled turn inside of smokebox.

Paragraphs 323 to 326 on settings and method of support are similar to the Rules. The Code says:

The lugs shall be so designed that the load is properly distributed between the rivets attaching them to the shell and so that not more than two of these rivets come in the same longitudinal line on each lug. The distance girthwise of the boiler from the centers of the bottom rivets to the centers of the top rivets attaching the lugs shall be not less than 12 in. The other rivets used shall be spaced evenly between these points. If more than four lugs are used, they shall be set in four pairs.

Lugs or brackets, when used to support boilers, shall be properly fitted to the surfaces to which they are attached. The shearing stress on the rivets used for attaching the lugs or brackets shall not exceed 8 per cent. of the strength given in Paragraph 16.

The Rules state that where three supports are necessary on each side of a boiler, an equalizer shall be used. The Rules also make provision for reinforcing plates where brackets are attached on portable boilers with directions for attaching same.

Paragraph 328 of the Code has a requirement not found in the Rules:

A water-tube boiler which is fired by hand shall have firing door or doors of the inward-opening type unless such doors are provided with substantial latching devices to prevent them from being blown open by pressure on the furnace side.

Paragraphs 329 and 330, the requirements for hydrostatic tests in the Code, are:

After a boiler has been completed, it shall be subjected to a hydrostatic test of 1½ times the maximum allowable working pressure. The pressure shall be under proper control, so that in no case shall the required test pressure be exceeded by more than 6 per cent.

During a hydrostatic test, the safety valve or valves shall be removed or each valve disk shall be held to its seat by means of a testing clamp and not by screwing down the compression screw upon the spring.

The Rules state:

When a boiler is tested by hydrostatic pressure, the pressure applied shall not be less than 1¼ nor more than 1½ times the maximum allowable working pressure; except that twice the maximum allowable working pressure may be applied on boilers permitted to carry not over 15 lb. pressure per square inch.

Paragraphs 331 to 334 regarding stamping are the same as the requirements of the Rules as far as it is possible for such a code to go without being incorporated into law. The Rules contain detailed directions regarding the procedure to follow to manufacture Massachusetts standard boilers, provision to insure that boilers are constructed in accordance with the Rules, data reports, annual inspections, certificates, etc., that each state that adopts the Code must incorporate and enforce.

Section 2, Part 1, treats in detail the subject of boilers used exclusively for low-pressure steam and hot-water heating and hot-water supply. The Rules do not deal at all with these. They apply to power and heating boilers except those exempted from inspection as follows: Boilers of railroad locomotives and motor-road vehicles; boilers in private residences and public buildings and in apartment houses used solely for heating, and carrying pressures not exceeding 15 lb. per sq.in. and having less than 4 sq.ft. of grate surface; boilers of not more than 3 hp.; boilers used for horticultural and agricultural purposes exclusively; boilers under the jurisdiction of the United States.

With the exception of the aforementioned provisions regarding hot-water heating and hot-water supply boilers, the provisions of this section of the Code as are covered by the Rules are practically the same. It will be necessary to obtain legislative action to extend the jurisdiction of Massachusetts authorities to cover the provisions of this section before they can be incorporated into the Rules.

The Rules have a requirement regarding the placing of a stop valve and a check valve on the return pipe of a gravity return system not in this section of the Code.

The main points of difference in this section relating to existing installations are the factors of safety allowed. The requirements of the Code are as follows:

Boilers in service one year after these rules become effective shall be operated with a factor of safety of at least 4 by the formula, Paragraph 378. Five years after these rules become effective, the factor of safety shall be at least 4.5. In no case shall the maximum allowable working pressure on old boilers be increased unless they are being operated at a lesser pressure than would be allowable for new boilers, in which case the changed pressure shall not exceed that allowable for new boilers of the same construction.

The age limit of a horizontal return-tubular boiler having a longitudinal lap joint and carrying over 50 lb. pressure shall be 20 years, except that no lap-joint boiler shall be discontinued from service solely on account of age until 5 years after these rules become effective.

Second-hand boilers, by which are meant boilers where both the ownership and location are changed, shall have a factor of safety of at least 5½, by the formula Paragraph 378, one year after these rules become effective, unless constructed in accordance with the Rules contained in Part 1, when the factor shall be at least 5.

Rules Factors of Safety

The Rules give the following requirements for boilers installed on or before May 1, 1908:

The lowest factor of safety to be used for boilers, the longitudinal joints of which are of butt and double-strap construction, shall be 4.5.

The lowest factors of safety used for boilers, the shells or drums of which are exposed to the products of combustion and the longitudinal joints of which are of lap-riveted construction shall be as follows: (a) 5 for boilers not over 10 years old; (b) 5.5 for boilers over 10 and not over 15 years old; (c) 5.75 for boilers over 15 and not over 20 years old; (d) 6 for boilers over 20 years old; (e) 5 for boilers the longitudinal joints of which are of lap-riveted construction and the shells or drums of which are not exposed to the products of combustion.

The lowest factors of safety to be used in calculating the maximum allowable pressure on boilers which were in the Commonwealth on or before May 14, 1909, and which are not Mass. Standard, or which have not been inspected, if hereafter installed, shall be as follows: 6 for boilers the longitudinal joints of which are of lap-riveted construction, diameters up to and including 36 in.; 8 for boilers the longitudinal joints of which are of lap-riveted construction, diameters over 36 in.; 5 for boilers the longitudinal joints of which are of butt and double-strap construction, age not exceeding 10 years; 5.5 for boilers the longitudinal joints of which are of butt and double-strap construction, age over 10 years. The hydrostatic pressure test on such boilers shall be 1½ times the maximum allowable pressure obtained by using the above factors of safety.

Paragraph 383 of the Code states that the maximum allowable working pressure shall not exceed 15 lb. per sq.in. on a boiler used exclusively for low-pressure steam heating. This is evidently meant as a definition to limit the pressure on a boiler not constructed in accordance with the rules for higher pressure. There should be no limit of pressure below the maximum allowable working pressure on a boiler that is used for heating only, if constructed for a high pressure.

The ultimate strength of rivets in shear, to be used for existing installations, is the same as given for new installations, and hence the differences previously stated apply here.

Paragraph 388 of the Code provides that the diameter of the rivet hole in a longitudinal joint of an existing installation may be found by cutting out one rivet in the body of the joint, a provision not specifically stated in the Rules.

Paragraphs 395 to 398, concerning gages are practically the same as Paragraphs 291 to 296, which points of difference with the Rules were previously discussed.

Paragraphs 402 and 403 state additional requirements regarding blowoff pipes, which are not found in the Rules for installations previous to the time these rules went into effect. They are as follows:

When the maximum allowable working pressure exceeds 125 lb. per sq.in., the blowoff pipe shall be extra-heavy from boiler to valve or valves, and shall run full size without reducers or bushings. All fittings between the boiler and valve shall be steel, extra-heavy malleable iron or extra-heavy cast iron.

When the maximum allowable working pressure exceeds 125 lb. per sq.in., each bottom blowoff pipe shall be fitted with an extra-heavy valve or cock. Preferably two valves or a valve and a cock should be used on each blowoff, in which case such valves, or valve and cock, shall be extra-heavy.

Paragraph 406 regarding feed piping varies from the Rules requirements for installations previous to May 1, 1908 as follows:

The feed pipe of a steam boiler operated at more than 15 lb. per sq.in. maximum allowable working pressure shall be provided with a check valve near the boiler and a valve or cock between the check valve and the boiler, and when two or more boilers are fed from a common source, there shall also be a globe valve on the branch to each boiler, between the check valve and the source of supply. When a globe valve is used on a feed pipe, the inlet shall be under the disk of the valve.

The corresponding provision of the Rules states:

Each boiler shall have a feed pipe fitted with a check valve, and also a stop valve or stop cock between the check valve and the boiler, the feed water to discharge below the lowest safe water line. Means must be provided for feeding a boiler with water against the maximum pressure allowed on the boiler.

The Code requirements for Lamprey fronts are the same as for new installations and differ as previously explained.

Paragraphs 408 and 409, for hydrostatic-pressure tests for existing installations is the same as for new installations and for which the discussion of differences likewise apply, with the exception that the required test pressure shall not be exceeded by more than 2 per cent.

There are provisions in the appendix, Paragraphs 428 to 430, for the location of fusible plugs, *if used*.

The requirements in the Rules regarding fusible plugs are very strict. Each plug shall be made according to specifications and shall be stamped Mass. Std. by the manufacturer. No fusible plug shall be used longer than one year. The required locations are the same as given in the Code for fusible plugs when used.

Higher Steam Pressures*

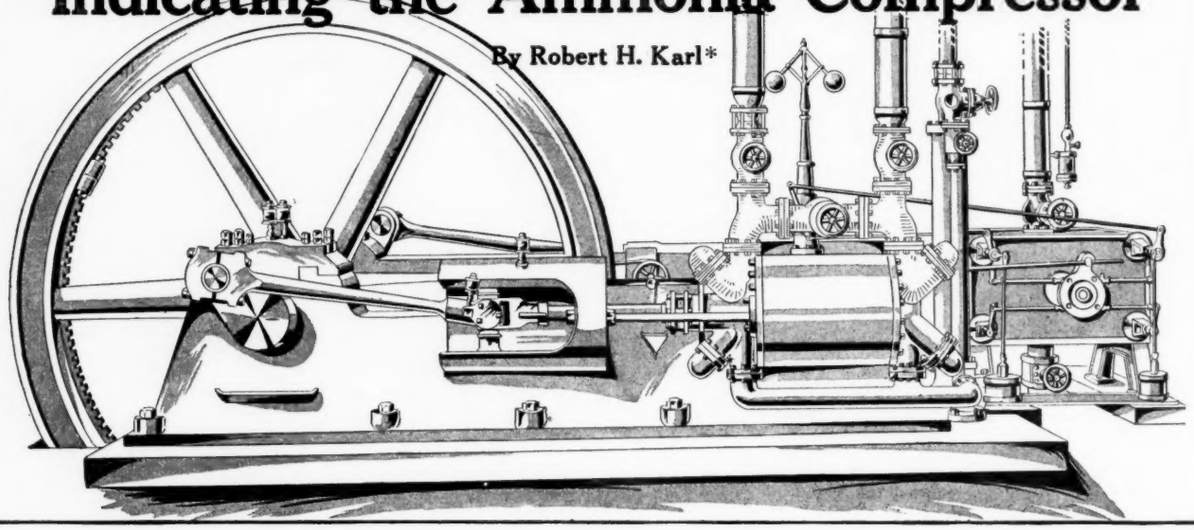
Since the laws of thermodynamics have been recognized by engineers as a sure guide to improvement of heat-engine economy, there has existed a tendency to increase the temperature range of the working fluid; that is, to increase the temperature at which the working medium absorbs heat and lower the temperature at which it rejects heat. This has led, in steam-engine practice, to the recognition of well-defined limits imposed by operating conditions—namely, a maximum temperature of 600 deg. F. and a minimum of 80 deg. F., corresponding to a pressure of ½ lb. per sq.in., or 29 in. of vacuum.

In the best present-day practice the maximum steam pressure is 200 lb. per sq.in., absolute, with a superheat of 200 deg. F. The corresponding temperature of evaporation is 382 deg. F., and the bulk of the heat is absorbed at a temperature 200 deg. F. below the maximum. It seems reasonable to expect that the approximation to the ideal Carnot cycle, and simultaneously the economy, would be improved by using higher pressure and less superheat; that is, by increasing the temperature at which the bulk of the heat is absorbed without increasing the maximum temperature. Steam pressures might be increased to 600 lb. per sq.in. without using temperatures higher than those employed in modern practice, and the difficulties encountered by the designer would not be formidable and would be more easily met than those of some types of explosion engines which have been successfully designed.

*Excerpt in "Journal of the Franklin Institute" from paper by R. Cramer, presented at the December meeting of the A. S. M. E.

Indicating the Ammonia Compressor

By Robert H. Karl*



SYNOPSIS—The first of a series of articles telling how to indicate the ammonia compressor, how to interpret the diagrams and what should be done to make the compressor operate as it should. This article explains and tells how to plot and use the adiabatic curve with which diagrams, in order to judge of how good or how bad they are, must be compared.

The best-known guides in determining whether the mechanical condition of a compressor or an engine is what it should be are pressures, and the indicator offers the best means of plotting a graphical record of the relative magnitude of the successive pressures and volumes inside the cylinder.

It is to be regretted that the indicator is not more commonly used to its fullest advantage; often it is applied carelessly. The best indicator kept in the best condition and operated by the most careful and intelligent man produces diagrams that are none too good. Indicator practice requires great care, both of the instrument and its method of attachment, since so much depends on a small area.

Defective valves and leaky pistons in a compressor, if permitted to run in this condition for long, needlessly waste much money, and these conditions in compressors are much more common than is generally supposed.

Figs. 1 and 2 are reproductions of ammonia-compressor diagrams, and upon looking at them as they are, what do they tell you?

They tell nothing. They are worthless, and that is the point I wish to bring out—that is, merely taking a diagram, if that is as far as you can go, has wasted your time. To make diagrams of value, the engineer needs guides—something to compare them with that he knows is all right—and these are the adiabatic curve and the isothermal curve.

(In adiabatic compression the gas neither gains nor loses any heat produced during compression. The adiabatic curve therefore represents this action. If the heat of compression is removed as fast as it is produced, the compression is said to be isothermal.) This was brought out well by F. E. Matthews in "Cold Storage and Ice:"

"Anyone can recognize a curve in a line that is supposed to be straight, without a straight line for comparison, but a variation in a compression or an expansion curve from the corresponding adiabatic or isothermal curve (which is only one of an indefinite number no two of which are alike because of their changing eccentricity) cannot be even approximately judged without the presence of the proper line for comparison. I think every engineer will admit the importance of this point, and I am safe in saying that less than ½ of 1 per cent. of the compressor-indicator diagrams taken ever have their compression lines compared with the appropriate theoretical curve.

"In the average steam plant with an engine working under nearly constant conditions, the variation of the expansion line from the hyperbolic is usually less and more nearly constant than that of a compression line from the adiabatic, and this will be found to be so of almost any compressor, no matter how uniform the load. This is because the conditions in the steam cylinder vary comparatively slightly in temperature and moisture, while those of ammonia in the compressor cylinder vary both

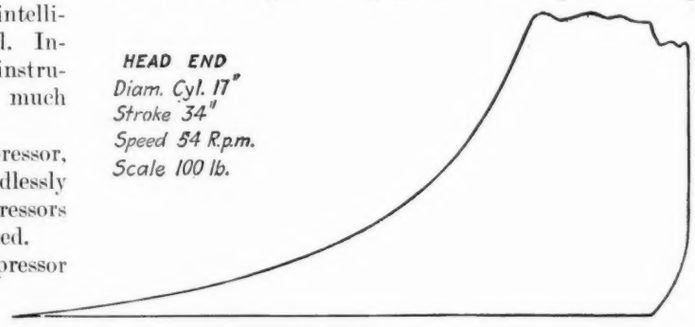


FIG. 1. A DIAGRAM THAT IS NOT AS GOOD AS IT LOOKS

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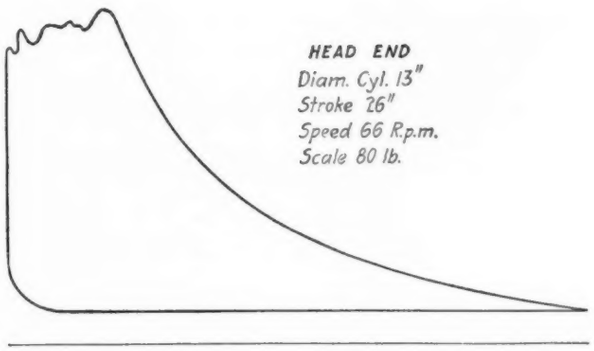


FIG. 2. ANOTHER GOOD-LOOKING DIAGRAM

in initial and final pressure every time a change is made in the expansion valves, speed of the machine varied, change in water temperature at the condensers, as well as the temperature and humidity of the atmosphere; performance is also subject to variations in humidity of the ammonia gas from the expansion coils. The fact that variations of humidity as well as pressures have their effect upon the ammonia indicator diagram, together with the fact that the poppet type of valves, which are more or less liable to stick, close sluggishly or leak, is used in compressors, makes it far more important that for intelligent interpretation, the theoretical curve be plotted on the card than that the hyperbolic curve be plotted on the steam-engine indicator card."

The before-mentioned variations often make the diagrams not only worthless, but also harmfully misleading—to one who depends on only a casual inspection of them, in trying to determine whether the compressor is giving the best results. But if these diagrams taken under varying conditions are properly studied and compared, much valuable information can be derived from them, and the conditions that are conducive to the best results determined.

Despite the value of the indicator, many compressors have no connections, etc., for attaching one, and a greater number of plants have no indicator; then again, some plants have a complete equipment for indicating and yet the engineer never uses it.

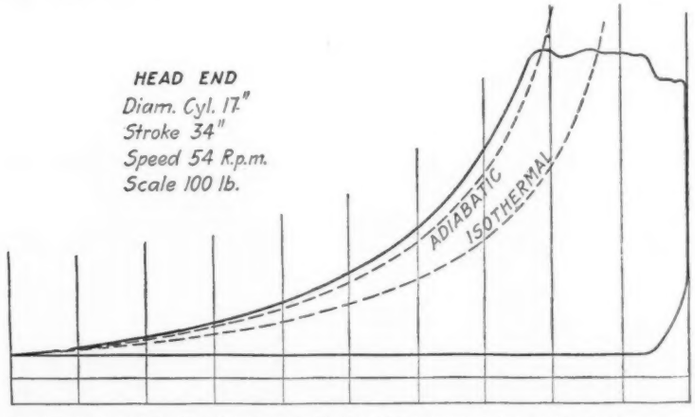


FIG. 4. ADIABATIC AND ISOTHERMAL CURVES DRAWN ON FIG. 1

There is nothing mysterious about a refrigerating machine. It is simply a heat engine reversed, or in other words, a gas pump. Thus a steam engine receives steam from the boiler, the source of heat, and rejects the exhaust steam into the condenser after extracting a certain portion of it in the form of work; similarly, the refrigerating machine takes a supply of working fluid from the cold body, does a certain amount of work on it and rejects it at a higher temperature to the condenser. The refrigerating machine is the agent used in transferring the heat from the refrigerating coils to the condensing water, and the work expended by the machine on the refrigerating fluid is that required in the transfer. It will be apparent that to get the greatest amount of work from this machine at the least cost, one must have a knowledge of indicator diagrams.

The indicator diagram will tell nearly everything that could affect the successful operation of the compressor when the adiabatic and isothermal curves are plotted on it and compared with the curves made by the indicator. It takes time, study and experimenting to be successful at this, but one will be amply repaid for the time so spent.

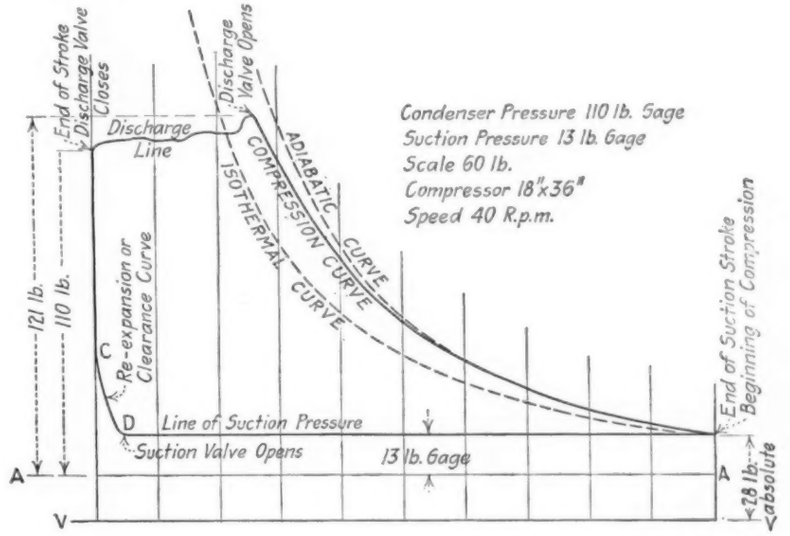


FIG. 3. DIAGRAM NAMING EVENTS OF THE STROKE

On the diagram, Fig. 3, the admission line is parallel to the atmospheric line. The compression line is a curve gently rising to the discharge line. The discharge line is generally peaked and wavy, due to discharge-valve vibration. The admission, or suction-pressure, line and the discharge line should be joined by a nearly vertical line. The diagram should have a nearly square heel.

The adiabatic and isothermal curves are also shown and will later be discussed.

Refer again to Fig. 1, which from a casual inspection does not reveal any serious defects. The clearance is small, and apparently everything looks all right. Referring to Fig. 2 in the same manner, this one shows a little more reëxpansion or clearance loss than should be, otherwise nothing serious is noticed. Further than this no engineer can go without the aid of the adiabatic curve. It is impossible to tell by a mere inspection whether the compression curves are good or bad in

Figs. 1 and 2. Should the compression curve be very bad, it might be readily noticed; even then probably no one could pass an opinion upon it that would be of real value.

The isothermal line is also a guide, though not as good as the adiabatic line, but I would advise that both lines be plotted. It takes but a few minutes longer and is

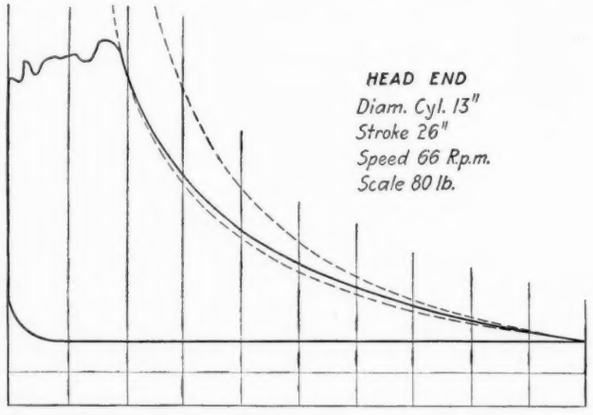


FIG. 5. ADIABATIC AND ISOTHERMAL CURVES DRAWN ON FIG. 2
Top is the adiabatic, bottom the isothermal

more than worth the time and trouble, as it makes the comparison more complete and interesting.

Figs. 1 and 2 are again reproduced in Figs. 4 and 5, having the adiabatic and isothermal lines plotted. These diagrams, which before apparently showed no serious defects (except perhaps Fig. 5, which shows a small reëxpansion loss), are here shown to be very bad cards. These machines were needlessly wasting much money, though their poor condition was not suspected, because the engineer lacked the knowledge for applying the proper curves to the diagrams to show him the true condition of the compressor. The following from Refrigerating Machinery, Vol. II, International Textbook Co., is worth consideration here:

"An adiabatic line is a curve that represents the adiabatic expansion or compression of a gas or vapor. Adiabatic expansion or compression is the expansion or compression of a gas or vapor without loss or gain of heat. During compression the pressure gradually increases until the discharge valve opens; the curve to which this change of pressure corresponds most closely is the adiabatic curve. The law for the adiabatic compression of ammonia gas is similar to that for air, but the coefficient k in the familiar formula $pv^k = p_1v_1^k$ has a value of 1.3 for ammonia, instead of 1.405, as for air, and the formula is therefore $pv^{1.3}$ where p equals initial pressure, v equals initial volume, p_1 equals final pressure, and v_1 equals final volume. Initial pressure times the 1.3 power of the initial volume is equal to the final pressure times the 1.3 power of the final volume, p and p_1 being absolute pressures.

"To construct the adiabatic curve from the formula $pv^{1.3} = p_1v_1^{1.3}$, it is necessary to calculate ordinates for the different points of the stroke. This involves the use of logarithms, which are not well understood by most operating engineers, and even if understood, require more time than can generally be devoted to that work. But the following simple method using Table 1 is available. In this table the pressure at the beginning of the compression stroke is taken as 1 lb. abs. The total cylinder volume is also assumed to be 1."

TABLE 1. ADIABATIC CONSTANTS FOR AMMONIA

Parts of Cylinder, Volume (1)	Absolute Pressure, Lb. per Sq.In. (2)	Parts of Cylinder, Volume (1)	Absolute Pressure, Lb. per Sq.In. (2)
1.00	1.000	0.50	2.462
0.95	1.069	0.45	2.824
0.90	1.147	0.40	3.291
0.85	1.235	0.35	3.915
0.80	1.337	0.30	4.783
0.75	1.454	0.25	6.063
0.70	1.590	0.20	8.103
0.65	1.751	0.15	11.778
0.60	1.943	0.10	19.953
0.55	2.175	0.05	49.129

"In column 1 are given the volumes for twenty positions of the piston, and in column 2 are given the corresponding pressures as calculated by the foregoing formula. The clearance can be disregarded as being too small to appreciably affect the results to be obtained. By means of Table 1 the absolute pressures for the given parts of the volume of any cylinder can readily be calculated by multiplying the corresponding values in column 2 by the initial absolute pressure—that is, the pressure in the cylinder when the piston starts on the compression stroke. For example, if the initial pressure is 30.7 lb. per sq.in., abs. and the gas is compressed three-tenths—that is, to 70 per cent. of its original volume—the value in the table opposite 0.70, or 1.590, is multiplied by 30.7, and the product 48.813 will be the pressure per square inch in the cylinder at that point."

The following illustration will make clear the application of the table when constructing an adiabatic curve:

"Let *ab*, Fig. 6, represent the curve of a properly operating ammonia compressor with a suction pressure of

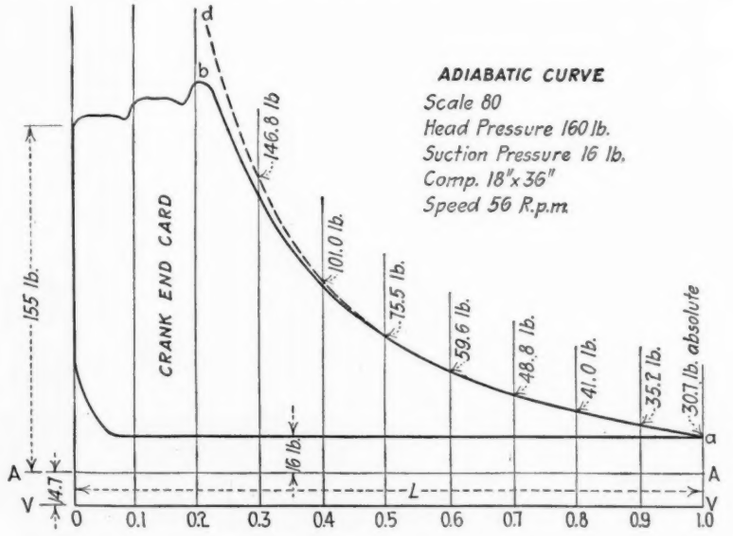


FIG. 6. EXAMPLE OF CORRECT AMMONIA COMPRESSOR DIAGRAM

16 lb. gage and a discharge pressure of 160 lb. gage. Let AA represent the atmospheric pressure line, L the length of the stroke and VV the vacuum line. Divide L into ten equal parts, erect vertical lines at these division points on the line VV, and number the points from 0 to 1 by tenths, as shown. Then the distance Va will represent the suction gage pressure of 16 lb. plus the atmospheric pressure of 14.7 lb., or 30.7 lb. abs. To get the point on the vertical line 0.9 for the curve, take

the value 1.147 from column 2, Table 1, opposite the 0.9 in column 1, and multiply by the initial absolute pressure of 30.7 lb. Thus $1.147 \times 30.7 = 35.2$ lb. per sq.in., nearly, which is to be laid off on the vertical line 0.9 from the vacuum line, to the same scale that *Va* represents 30.7 lb. In this case the pressures have been

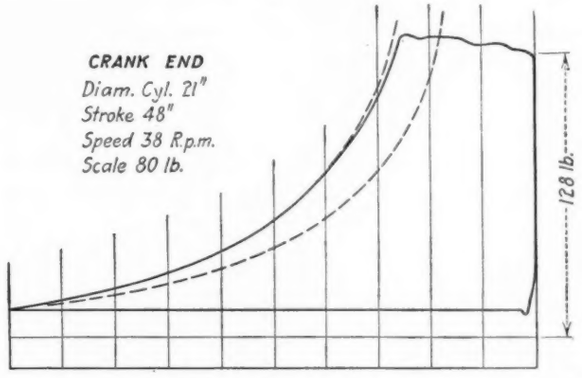


FIG. 7. HOW EXPANSION LINE WOULD FOLLOW ADIABATIC CURVE IF THERE WERE NO LEAKS

laid off to the scale of 80 lb., which was the scale of the spring used in taking the indicator card. Next take the point 0.8 and find the corresponding pressure, column 2, to be $1.337 \times 30.7 = 41.04$ lb. nearly; then in a like manner do the same for 0.7, 0.6, 0.5, etc. When all the points have been located, the curve *ad* may be drawn through them as shown by the dotted line *ad*, which is the adiabatic curve.

"If the ammonia gas were compressed from the point *a*, Fig. 6, up to the condenser pressure in a perfectly tight and nonconducting cylinder without loss or gain of heat, then the adiabatic line would be the curve traced by the indicator pencil. If there is no leakage past the valves or piston, the compression line will in all ammonia compressors almost exactly follow the adiabatic line, departing from it only as shown in Fig. 7."

It makes no difference whether the compressor is single-acting or double-acting, or operating on the wet-or-dry principle, if it is in good condition the compression curve as traced by the indicator pencil will closely follow the adiabatic line. The only operating condition that could cause the compression curve to lie below the adiabatic curve, if the compressor is in good condition with no leaky valves or piston, would be an excessive amount of liquid ammonia. In this case the compression curve will drop toward the isothermal curve. The ammonia compressor was designed to pump ammonia gas and not liquid ammonia.

Fig. 7 shows the compression curve following the adiabatic curve closely, or how it would follow if the compressor were in first-class condition. The compressor from which Fig. 6 was taken is also in first-class condition.

[*The next article of this series fully explains the plotting and use of the isothermal curve.*—Editor.]

Novel Type of Generator

The illustrations show a working model of a novel type of generator designed and patented by Joseph Bell, of Cincinnati, Ohio. This machine has an armature revolving in one direction and the field in the other. The casings, or supporting bodies for these elements, are of equal diameter and of approximately equal weight to operate as flywheels. Each element has a direct piston connection with a reciprocating prime mover. It will be evident that the relative speed of the generator is double that of the prime mover.

Over the standard generator the machine should possess the advantages of reduced weight and space occupied and should deliver double the energy produced by a standard machine driven at the same rotative speed. The driving mechanism is of course in duplicate and consequently more complicated.

It will be seen that the machine has four bearings, two cranks and, in the present case, an eccentric to control the steam valve. A throttling governor regulates the steam supply. Commutation is effected in the usual way with modified designs of commutator or slip ring.

The present model is designed for alternating current, but the inventor intends to build direct-current machines of the same general design. The exciter is to be mounted on the top crosshead guide. The inside edges of the flywheels are beveled to receive a rawhide friction pulley

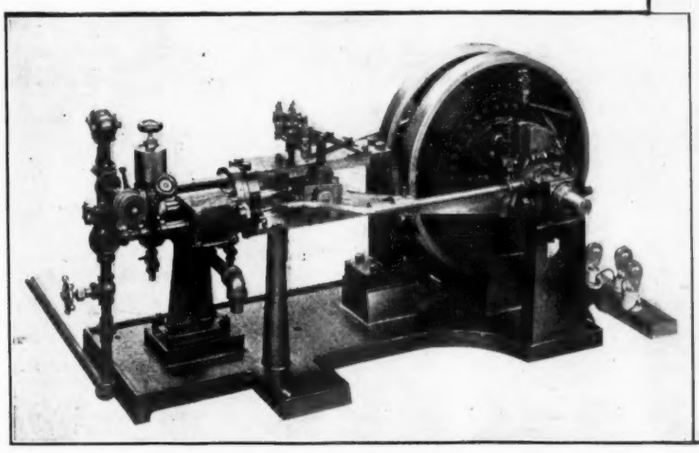


FIG. 1. SIDE VIEW OF ENGINE AND GENERATOR

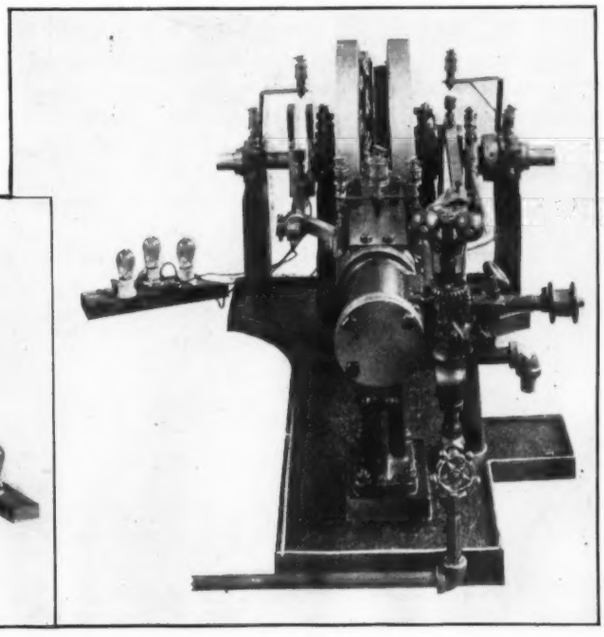
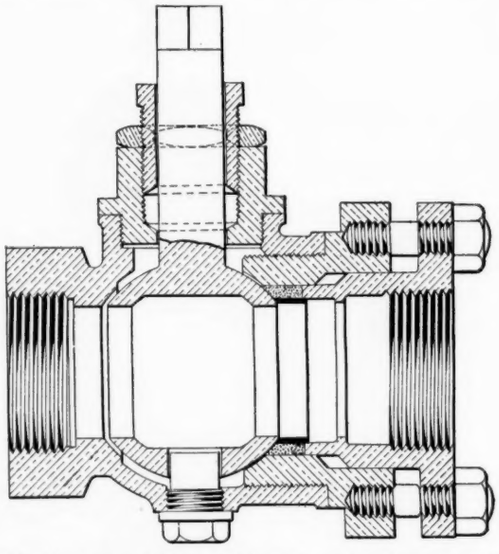


FIG. 2. END VIEW OF UNIT

mounted on the exciter shaft. When this feature has been perfected, the machine will be entirely self-contained. It is the intention of the designer to build a larger experimental machine with the idea of bringing out any defects that may be inherent with the new type of machine.

Improved Howard Ball Blowoff Valve

The accompanying illustration shows the improved Howard ball blowoff valve as now manufactured by the American Steam Gauge and Valve Manufacturing Co., Boston, Mass., which has recently taken over the valve



SECTION THROUGH HOWARD IMPROVED BALL BLOWOFF VALVE

that was formerly made by the Howard Iron Works. It was described on page 228 of the Feb. 13, 1912, issue.

The improved valve differs from the original design in that the hollow bronze ball with openings at opposite sides is now made in one piece with the valve stem, instead of having the stem screwed into the top of the ball and prevented from turning in it by a pin. This pin gave trouble by shearing, thus making the valve useless. With the one-piece ball and stem this annoyance is overcome.

A second improvement is the guide nut at the bottom of the valve body. This aids in keeping the valve ball in line with the valve stem stuffing-box and in contact with the packing shown at the right-hand stuffing-box, so that no matter how the valve ball is turned, its outside surface will make a tight contact with the packing in the stuffing-box.

The packing used is known as "Bakelite" and has such properties as to keep its bearing surface smooth and polished and at the same time prevent wear on the ball where the bearing occurs.

To prevent the stuffing-box gland on the valve stem from turning with the stem, a locknut is used, as shown.

Corrosion of Pipe in Service

Considerable interest has of late years been centered in corrosion, chiefly because many experimenters have made discoveries of value in preventing and retarding corrosion.

In the Feb. 29 issue of *Power* there appeared an abstract of a paper on "The Prevention of Corrosion in Pipe," by F. N. Speller, metallurgical engineer for the National Tube Co., read before the recent annual meeting of the American Society of Heating and Ventilating Engineers. The following table giving a résumé of results of investigation of corrosion of iron and steel pipe appeared in that paper, but did not appear in the abstract.

Since experiments have shown how oxygen in water assists corrosion, means of liberating the water of as much of it as possible have attracted attention. The deaërating tank, Fig. 3 of the abstract of Mr. Speller's paper, shows its application to a hot-water heating system. Its efficacy is greater in hot-water supply systems, where more air is found in the water than usually accompanies water in a heating system of the kind usually found in buildings.

RESULTS OF INVESTIGATIONS OF CORROSION OF IRON AND STEEL IN SERVICE

No.	Date	Locality	Length of Time Pipe Lines Were Installed	Character of Service	Authority	Number of Cases on Record	Average of Deepest Pits W.I.	Average of Deepest Pits Steel	References for Details and Remarks
1	1910	New York City bath-houses	3 yr. and over	Hot-water supply service	Prof. Ira H. Woolson, Columbia University	89 samples secured, of which 17 are wrought iron and the remainder steel	Equal 100 per cent.	Equal 100 per cent.	"Eng. News," Dec. 3, 1910, p. 630; N.T.C. Bulletin No. 2. This was a test of iron and steel pipe in actual service continued to destruction
2	1910	Frick Coke Co. power plants	6 mo. to 7½-8 yr., varying with the comparisons secured	Boiler-feed water lines	Research laboratory National Tube Co.	21 lots comprising 52 samples, of which 26 are iron and 26 steel	0.112 in. 100 per cent.	0.108 in.* 96 per cent.*	"Eng. Review," April, 1911; N. T. C. Bulletin No. 3; Amer. Soc. Heating and Ventilating Engrs., 1911. Pipe samples secured from lines in actual use. In 22 cases of adjacent iron and steel pipes in same lines, 13 comparisons favor steel and 9 iron
3	1911	Cresson (Penn.) coal fields	6 mo. to 10 yr., varying with the comparisons secured	Hot- and cold-water boiler-feed lines; pump-discharge lines	Research laboratory, National Tube Co.	9 comparisons of iron and steel found together	0.100 in. 100 per cent.	0.085 in.* 85 per cent.*	Pipe samples secured from lines in actual use. In 9 cases of adjacent iron and steel pipes found in same lines, 4 comparisons favor steel and 2 iron; in 3 cases the steel and iron are equally corroded
4	1911	Allegheny General Hospital	Between 7 and 8 yr.	Hot-water supply service	Research laboratory, National Tube Co.	69 samples from hot-water lines, 42 wrought iron and 27 steel	0.105 in. 100 per cent.	0.105 in.* 100 per cent.*	Conditions those of actual service, and pipe was tested to destruction. In 13 cases of adjacent iron and steel pipes found in same lines, 7 cases favor steel and 6 iron
5	1911	New England investigation	2 to 17 yr., varying with the comparisons secured. Average, 9 yr.	Hot and cold water, live and exhaust steam, brine, boiler blow-off lines, etc.	Dr. W. H. Walker, director research laboratory of Applied Chemistry, Massachusetts Institute of Technology	54 comparisons of iron and steel found together, in hot-water and steam lines	0.069 in. 100 per cent.	0.063 in.* 91 per cent.*	"Eng. News," Dec. 21, 1911; "Jour. of New England Water Wks. Assn." Jan., 1912. Actual service conditions. In 54 cases of adjacent iron and steel pipes found in same line, 20 favor steel and 18 iron, 9 show no difference in corrosion and 7 no corrosion at all
6	1913	New York City hotel investigation	6 to 10 yr.	Hot-water supply and steam-return lines	Dr. Wm. Campbell, Columbia University, co-operating with research laboratory N. T. Co.	From 60 samples 9 comparisons of iron and steel were found	0.095 in. 100 per cent.	0.067 in. 70.5 per cent.	Conditions those of actual service, pipe used to destruction. The iron samples failed in 20 spots; the steel failed in 2 places; due to pitting

Depth of pitting in wrought iron samples considered as 100 per cent. in all cases. *Calculated from the deepest pit in each sample.

Editorials

Outside and Inside Assistance

Brains are necessary to economic power-plant operation. They may be supplied either through outside experts or within the working force and organization of the plant. The larger plants realize the advantage of employing both kinds, and the smaller installations are rapidly falling in line. Still too common, however, is the management which boasts that it never has to call in outside help. An efficient organization can cope with all ordinary problems, but there are times when a new point of view is invaluable, particularly if the problem is unusual.

Some are against calling in the outside expert on the ground that in the plant organization each individual has his specific duties and operation is so dependent upon mutual coöperation that bringing in one not familiar with all the details is apt to cause disorganization that may far outweigh any possible benefits. Such an excuse is exceedingly lame. A system so complex that an expert engineer familiar with other organizations of equal or possibly greater efficiency cannot readily grasp it is impractical, and the plant having it needs outside brains more than any other.

The imported expert need not neglect regular duties or leave them to others while he attacks the problem, and he can do it with a clear, unbiased mind. Nor is he embued with the regular employee's regard for any prevailing system, which may indeed have been at least the indirect cause of the trouble. Certainly the probability of any disorganization to general operation is less through the newcomer than if this service had been demanded of the regular force, no matter how expert or well-qualified it may be to cope with the situation.

Many large industrial plants realize the value of outside assistance—the unbiased and fresh viewpoint—and retain consulting engineers to whom the out-of-the-ordinary knots are referred for untying and whose duty it is to better the efficiency of the plant in all possible ways. Here again there is danger. Such an expert may have so much work thrust upon him that he virtually becomes a part of the organization and fails eventually to supply the unbiased, fresh viewpoint for which he was employed. Frequently it would conduce to increased plant efficiency to refer some of the problems for which the consulting engineer is regularly employed to another. Organization and system are indispensable to efficient operation, but they also tend to subordinate individuality and keenness of perception.

All ordinary problems should advisedly be solved within the organization of an efficiently managed plant. Every incentive should be given for the improvement of the individual, to better his position, increase his efficiency and to become more valuable to the establishment, but when the unusual problem arises the truly efficient plant should call in assistance from outside—an expert who is unfamiliar with the ordinary routine of the plant. Instead of a large plant having one consulting engineer, general economy and efficiency may frequently be realized by calling in a new expert. A family doctor on whom implicit reliance has been placed for years may fail in diagnosing the patient's ailment, and the individual has no hesitancy in consulting an expert. Too great familiarity with the power plant may, likewise, reduce the regularly employed expert's power of diagnosing ailments and suggesting remedies—a trained mind with a new point of view should be consulted.

Consulting with Subordinates

The desire to work out problems upon one's own responsibility sometimes leads a chief engineer to withhold from his subordinates opportunities to share investigations that would be of great mutual benefit. Not seldom, minor inquiries have to be set aside temporarily by a plant chief while he devotes himself to something demanding immediate attention. In such situations it would often be well if those next in command were given a chance to exercise their abilities in super-routine work. Control of methods and conclusions need not depart from the chief simply because those below him in authority are intrusted with a measure of advisory or inquisitory responsibility, and meanwhile the best interests of the plant are served by the expedition of its business thus accomplished.

No doubt in ordinary operation and even in dealing with maintenance questions, the practice of relying upon the special knowledge and abilities of assistant engineers is widely favored. But there is another class of work which the chief engineer is tempted to let accumulate until he has time to handle it, even if it piles his desk with unfinished business. A good many engineers have yet to learn that nothing develops the efficiency of their subordinates more than responsibility. The former sometimes fail to realize that the more efficient their assistants are, the more credit they themselves are sure to get from hard-headed superiors. No executive of modern stamp today expects a chief engineer of a sizable plant to have a monopoly of intelligence, although he is supposed to have superior judgment and presumably more comprehensive experience than the men under him, as individuals. It cannot be too strongly emphasized how much credit an engineer gets for building up an efficient organization and leaving himself some time in which to study the broader problems of station economics.

Many a valuable suggestion comes to light through giving the subordinate engineer a chance to work out some of his ideas under the eye of the chief. To allow work to languish through lack of time to handle it personally when it might be utilized in at least covering the preliminary fields of inquiry is of doubtful wisdom. Often an under engineer can be turned loose in the preparation of preliminary statistics, in searching for methods and results in other plants which will throw light upon the special problem, in the devising of

apparatus for unusual tests, or in the close scrutiny of certain phases of station service to the immense advantage of the later work of compilation, discussion or interpretation by the chief himself. Rough preliminary calculations performed by a subordinate engineer often can be made to show the best lines of attack on the big problems to follow. Such opportunities arouse the coöperative enthusiasm of ambitious under-men, lead them to devote outside time to the study of specialties, add weight to their individual judgments and increase their interest in the plant's welfare. Latent ability yields to the warmth of confidence and deserves every encouragement possible.

Early Buyer Gets Deliveries

The present constantly increasing activity in manufacturing and industrial establishments is throwing greatly increased loads on existing power plants. In consequence many are installing new equipment to provide for additional capacity.

Expansion of this kind naturally means a tremendous increase in the demand for supplies, equipment and all materials entering into power-plant work, and when it is so sudden and of such unprecedented volume as at present, it further follows that the demand for a time greatly exceeds the supply. As a result normal deliveries cannot be secured, bonuses are exacted for prompt shipment, high prices prevail, and in general the problem of securing material when needed at reasonable prices is serious.

All this suggests the extreme advisability of so planning and arranging purchases for general supplies and for new equipment that ample time—much more than in normal periods—is allowed for obtaining deliveries without incurring the payment of extras, bonuses, etc., and the expense due to hold-ups and delays.

The greater volume of business also means more traffic on the common carriers and more than ordinary delays in shipment, freight embargoes, car shortage, etc.—all of which must be taken into account when scheduling deliveries.

The wise ones are arranging to get their orders for material placed early—extra early—and thus avoid much additional expense, loss of time and worry.

Congress and Water-Power Legislation

The water-power situation appears little nearer solution than several years ago, when the public began to awaken to the importance of keeping some measure of control over its great resources. No less than eight bills fair to both the public and the corporative interests have been defeated and substitute measures framed, only to be defeated in turn by the conservation element. Thus the controversy has waged, the water-power interests determined apparently to accept all or nothing and the opposition equally determined to oppose any measures that do not adequately protect the public's interests.

In the present Congress the Ferris bill, a good bill, twice passed the House but met defeat in the Senate. The Shields bill passed the Senate but failed in the House, and a substitute measure, a little better but still leaving much to be desired, has been offered. At the same time a thoroughly vicious measure, the Myers bill, has been offered in the Senate. The opinion is held by those in close touch with the situation that the House bill and the Senate bill will go to conference for adjustment of the differences. Those managing the campaign for the water-power interests hope that a majority of the conferees will be friendly to them and will report a bill in their favor; in which event an attempt will be made to rush it through in the confused and crowded final hours of the session.

The Ferris bill and other similar measures were reported to have had the indorsement of the administration. In fact, on several occasions the President expressed himself as in sympathy with legislation that would protect the public's interests without retarding development of the water powers. It is unfortunate that more active support was not given these bills at the time by the Administration, but the opportunity has not passed and it is hoped that the President may see his way clear, even amid the present international problems, to come out actively in support of some good bill that will settle the problem in the proper way. What is done now in the water-power situation will be felt more twenty years from now than at present, but it will then be too late to rectify a false step. Let us pause to look over the present oil and coal situation before relinquishing any more rights over natural resources.

This week a meeting of the American Institute of Electrical Engineers will be held in Washington to consider questions of water-power development as related to national efficiency and preparedness. In view of the active part being taken by the national engineering societies in the preparedness program, such a meeting is timely.

Quoting from the official announcement of this meeting, the Committee on Development of Water Power of the Institute "sees a further opportunity for service to the nation by directing the attention of the public and of Congress to the fundamental engineering and economic principles that underlie the water-power question and which must be taken into account if hydro-electric development is to be encouraged and developed."

The opportunity for service is there, and the American Institute of Electrical Engineers cannot afford to view the problem in other than the broadest sense, notwithstanding the associations and sympathies of some of its prominent members.

Electric Irrigation During the "Hopeless Valley" of the Central Station Load Curve.—Headline. Smoothing out the topography by inundation, as it were.

Because of the war mercury prices have literally soared; therefore we contend that the mercury boiler would cripple industry on the outbreak of national hostilities. Already we have visions of engineers opening the blow-offs and selling the precious metal to the highest belligerent bidder. Now that we think of it, what in the world has become of W. L. R. Emmett's mercury?

We commend some courageous inventor to the task of developing a gage-glass for lubricators that will not cloud or gum up.

Just think how much good organized engineers in and around big cities would do for themselves if they played engineering more and politics less!

Correspondence

Difficulty with Suction Line

The difficulty Mr. Arnois experienced (*Power*, Dec. 21, 1915, p. 867) because his centrifugal pump did not create the same vacuum as that in the main suction line was primarily due to the absence of the water-seal rings in the packing glands.

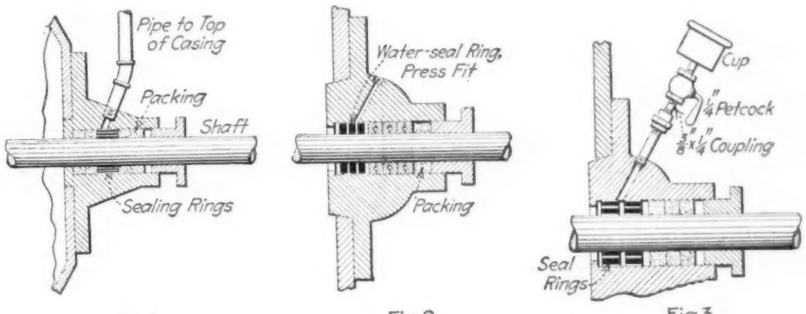
It is easy to pack the shaft of a centrifugal pump against ordinary pressure, when in good condition, but it is difficult to pack against a vacuum of 29 in. Under the latter condition the shaft and packing may be dry in starting and will readily admit enough air to lower the vacuum. In Mr. Arnois' case a small leakage would reduce the vacuum 0.8 in., which was the difference he found on applying the gage. This was enough to prevent the pump getting water.

This leakage is increased in many instances by the shaft (which is usually of steel) becoming pitted in the glands by the corrosive action of the liquid handled—especially salt water or water in a hot-water heating system when the pump is used for forced circulation. This pitting causes the shaft to become rough and cut the packing, making it more difficult to maintain a tight joint to hold high, dry vacuum in starting; the pits also aid in working air through the packing when the shaft is revolving. In the case mentioned the vacuum was high and there was enough air leaking in around the packing to prevent the ejector from producing the high vacuum in the pump chamber necessary to cause the water to flow into it.

A centrifugal pump designed for high suction lift has a long packing box in which a water-seal ring is placed, as shown in Fig. 1. This seal is connected by a ⅜-in. pipe to the upper part of the casing, or in some instances to the discharge pipe, where a supply of water is assured. The packing between the sealing ring and runner permits but a small amount of water to be short-circuited back from the discharge to the suction, and the packing outside of the ring prevents external leakage. These glands should be run loose enough to allow a little external leakage, say 8 or 10 drops per minute, to act as a lubricant to keep the packing from wearing excessively, prevent it from heating and, by filling the voids in the packing, prevent air from being drawn in when running under a high vacuum.

A new 4-in. motor-driven single-stage unit was erected in a plant by a millwright who did not know that water-seal rings were required in the packing glands. The unit was assembled in the factory, and the only work required to get it running was to connect up the suction and discharge pipes, pack the glands and wire up the motor. He observed that the boxes required considerable packing, but could find no use for the "small brass spools" sent with the pump. The pump would not lift water 4 ft. without priming, and as no ejector is provided with these small pumps, a priming pipe was connected to an overhead tank for use in starting. After the unit was put into operation, it would throw a full stream for about half an hour, then the discharge would gradually decrease and in about an hour would cease. The pump then had to be stopped and reprimed. After the water-seal rings were put in place and the packing cut in rings to fit the shaft—instead of being put in in one long piece wound around the shaft until the box was full—no further trouble was experienced from the pump losing its water.

In some pumps of the older type these water-seal rings are placed at the bottom of the gland, as shown in Fig. 2,



FIGS. 1 TO 3. DETAILS OF SEALING RINGS FOR CENTRIFUGAL PUMPS

instead of in the middle of the packing. They are pressed into the casing and are a neat fit on the shaft. With this arrangement, as the shaft and gland wear, more water will be bypassed from the discharge side to the suction, especially where the head is high. In this type the packing is not so well lubricated and has a tendency to heat and burn out.

We are operating two 8-in. volute pumps of this kind, used alternately, for circulating the water in the hot-water heating system. The pressure is about 40 lb., and the difference in pressure between the suction and discharge is about 4 or 5 lb. The glands are of the type shown in Fig. 2, no water-seal pipes are used, nor are they necessary, because the suction being under pressure, water can work in through the water-seal rings to the packing; provisions have been made for them, however.

After being in intermittent service for 5 or 6 years and standing idle during the nonheating season, the shafts became so badly pitted in the glands that ordinary packing would last but a few days. New shafts were made for them, and instead of using the water-seal for lubricating the packing, a 4x⅜-in. nipple was screwed into the opening and a grease cup attached to it. The idea is shown in Fig. 3.

Some of the grease works into the heating system, but as there is 40 lb. pressure tending to force it back through the packing, we believe that by allowing the packing to drip a little it will be more effectively lubricated, as the pressure will force the grease into the packing, and the chances of the new shaft becoming pitted will be lessened.

To prevent the grease from getting into the system in such quantities that the efficiency of the radiating surface might be lowered, only a small amount of the best mineral grease is used, about two No. 1 cupfuls per week on each gland on the 2-in. shaft.

This plan has been in use only since the system was started this season, but seems to be working satisfactorily. The packing wears better, the shaft turns easier, and the grease is working out through the packing to some extent.

Hyattsville, Ind. J. C. HAWKINS.

Questions Rating of Turbines

In a letter in the Feb. 22 issue on steam-turbine operation, the author, Mr. Brookins, stated that at the time of the evening peak loads two 2,000-kw. turbines were carrying 3,200 kw. each and that the boiler pressure had dropped from 175 to 145 lb. and the vacuum from 28 in. to 25 in.

In my experience operating different types of steam turbines and engines, I have not seen one that would carry such an excessive overload under the conditions stated by Mr. Brookins. I have yet to see the machine properly designed that will carry even normal load with a very great drop in boiler pressure; turbines especially lose their speed rapidly when the vacuum starts to fall.

Fall River, Mass. M. J. MONTEITH.

Put It Over Naval Engineers

Here is an installation that furnishes a good reason why the oil engine is not better received. Two cranes were contracted for—one for Pearl Harbor and the other for Boston. The idea is to use electricity from storage batteries for hoisting and placing the weights handled. The batteries are charged from a power plant on the crane. Since this is a floating crane and may be needed away from the Navy Yard, it is essential that some plant be placed on it for the generation of power. As the action is intermittent, it is a wise provision to have an internal-combustion engine. Three-cylinder 270-hp. Diesel engines were used.

When the contract was closed, the following guarantee was made by the engine builders:

> The consumption of fuel (either crude or fuel oil) shall not exceed 8 gal. when running at any load between rated capacity and half-load per each 100 b.hp.-hr. (this being equivalent to 0.6 lb. of oil per b.hp.-hr. when running at any load between rated capacity and half-load). The gravity of this crude or fuel oil must not be heavier than 19 deg. Bé. scale, and it must be free from acid and from foreign matter and contain not more than ½ of 1 per cent. of sulphur or water.

According to this guarantee the builders promise that the engine shall be able to run on any fuel not heavier than 19 deg. Bé., or 0.94 sp.gr. Under this performance the engine would be very economical. However, when the engine was set up in the crane to be adjusted, in place of some grade of fuel oil being used, the engine was adjusted and turned over to the Government on fuel of the highest grade. This was raw crude oil of paraffin base from the Freedom Oil Co., of Freedom, Penn. This oil cost around 17c. a gal. delivered in 5-gal. lots at the navy yard. The use of such a fuel did away with the advantage of the high-priced engine installed. It can be said that the officials were asleep. Let that be so, were not the engine people more neglectful of their chance? At the navy yard there was no one who was officially qualified to pass upon the oil engine. Was it to the credit of the engine builders to put one over on a prospective big buyer of such magnitude as the United States Government? Would it not have been better policy to have done all that was possible to make this engine establish a record for itself?

After running awhile on this expensive fuel, the fuel oil in the navy yard was tried. This fuel came within the guarantee. I cannot personally vouch for this fact, but I was informed that 10 gal. was put in the tank and the engine given a trial. I was also informed that the trial was a failure and that the tank was washed out with gasoline. Whatever is the condition, gas oil is now used for fuel.

I have my doubts if the oil specified can be used in this type of engine. The reason for this belief is that the fuel valve is called for to be jacketed with water which must always be cold to the touch. If this grade of fuel is to be used (19 deg. Bé. scale) the oil should be warmed, and the valve as a result must be kept warm or hot and not kept as near 60 as possible.

Another point is to be drawn from this installation. Here again the Diesel simplicity was shown. In this plant there was ample storage-battery capacity, yet the air compressor was belt-driven from the main engine. The expected happened when the engine gave trouble. The air for starting was used up before the trouble was located. The result was that an electric motor had to be installed to build up the air pressure again. It is my opinion that the air compressor should not be driven from the main engine, but should be driven by an auxiliary. This would have been a very simple matter with the large storage-battery capacity. With a new device great care should be taken to insure perfect reliability. This could have been obtained with an electric-driven air compressor.

The faults met with in this installation, while not serious, are annoying and could have been avoided by a little foresight on the part of the builders. These builders are not unique, but their policy seems to be the policy actuating all oil-engine builders and seems to be clearly the reason why the oil engine is not more popular. My faith in the oil engine is far greater than in the present builders of the engine. JOHN WENTWORTH.

Quincy, Mass.

Boiler-Setting Explosion

An unusual explosion occurred in a plant of which I had charge. A foundation for a boiler had been prepared according to specifications with the exception of the floor of the combustion chamber. This should have been made of two layers of brick, the lower of common red brick laid on a bed of sand and the upper of firebrick grouted with fireclay. By some misunderstanding a 4-in. slab of concrete had been used instead of the bed of sand, and the fill consisted of cinders. These were taken partly from boilers in use and, being hot, considerable water was used to cool them.

When the boiler was completed and the brickwork thoroughly dried, steam was raised to the working pressure of 150 lb. In about two hours a violent explosion occurred. Investigation showed that the floor of the combustion chamber had been blown upward with sufficient force to bend the lower row of tubes, destroying considerable of the baffle tiling. In my opinion the water

in the cinders had been evaporated into steam, and as there was no way in which this could escape, the pressure increased sufficiently to cause the disruption of the concrete slab. There were other boilers in the plant set in the same way as far as the floor of the combustion chamber was concerned, but no difficulty had occurred.

Another theory was advanced to the effect that gases had been formed from the unburned combustible in the ashes, but as the ashes were in a practically air-tight chamber, it is hardly possible that such a pressure could have developed. Fortunately none of the tubes pulled out, though a few leaked badly where they were attached to the rear water leg.

FRANK H. WILLIAMS.

Jersey City, N. J.

Reducing the Pressure on Economizers

I was interested in the editorial in the issue of Mar. 28 in regard to economizers. I wish you had gone farther and said whether you think that economizers should be run, as they usually are, under pressure. In almost all cases they are run above boiler pressure and after a few years give trouble.

It may be of interest to know how we are running the economizer at our Washington Mills. We have one large Green economizer, 1,600 pipes, which has been in use a great many years, working under a pressure of 185 lb. It had arrived at a stage when it either had to be discarded or renewed. The renewal meant a large expenditure. The scrapping of it meant a great loss to the company. In thinking the matter over I saw no reason why I could not reduce the pressure on the economizer and still keep it in service. I applied another pump, and I am running it today under 10 lb. pressure, taking the water from the economizer at that pressure, with another pump pumping into the boiler at 185 lb. This economizer has been running now for nine months without giving any trouble. Before, pipes had to be changed every week. I think all economizers should be run under these conditions.

GEORGE H. DIMAN,
Consulting Engineer, American Woolen Co.

Lawrence, Mass.

Dust on the Motor Slip-Rings

In powder plants sparking current collectors, whether they may be the brushes of direct-current machines or those of alternating-current machines, are always a source of danger. As alternating-current motors are comparatively easy to maintain sparkless, they have largely superseded direct-current motors in this industry. In either application it is customary to locate the motors as far as practicable from the driven machines that handle the explosive. The controllers or the compensators are oil-immersed, and where resistances are used, they are located in well-protected external housings that should be well ventilated.

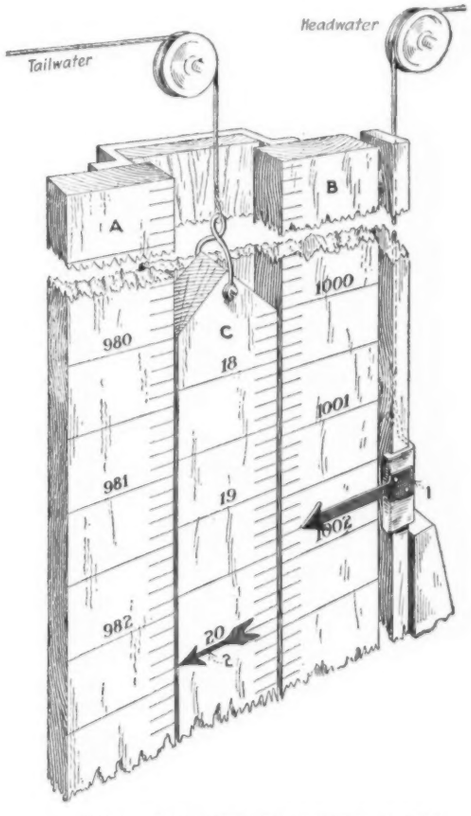
An operator complained that on starting a newly installed induction-motor unit used for driving the cylinders in which the powder is glazed, the motor slip-rings sparked and the rotor resistors heated more than he considered safe amid such surroundings. As far as the heating of the resistors was concerned, it would not have been considered objectionable under ordinary conditions, although the inclosure afforded no air circulation for cooling. As the powder mill represented an exceptionally exacting condition, however, the heating was reduced by ventilating the inclosure, top and bottom. The applying of instruments indicated that the motor was nowhere near full load and that the starting current was well below the permissible limit, the load being taken up through a clutch after the motor was up to speed.

As repeated attempts proved that it was impossible to get any evidence of sparking at the brushes, even when the motor was started with the load clutch in, it was concluded that the initial sparking that had alarmed the operator was due to an accumulation of finely divided powder dust that had settled on the collector between the times of installing and of starting the motor.

Schenectady, N. Y. E. C. PARHAM.

Water-Level Indicator

The illustration shows a water gage that I have devised for the water-power station here, which may be of interest to readers of *Power*. The boards *A* and *B* are stationary, while slide *C* and arrow 1 are moved by floats in the head



TWO-POINT WATER-LEVEL GAGE

and tailrace. The arrow 1 shows on board *B* the elevation, above a datum line, of the water in the penstock. The arrow 2 on *C* pointing to *A* shows the elevation of the water in the tailrace. The reading on *C* opposite arrow 1 is the difference in level or head in feet. Indicator 2, painted on board *C* in the illustration, shows on board *A* the water in tailrace to be 982.4 ft. and the sliding indicator 1 shows the head water to be 1,001.8 ft. (on board *B*) and also shows the effective head on board *C* to be 19.4 ft.

The end view shows the construction of the gage boards. *A* and *B* are held together by strap iron bent so that a blank board is fastened with ¼ in. space between its face and the backs of boards *A* and *B*. On the back of board *C* is fastened a piece of ⅛x1-in. iron the ends of which slide between the inside edges of boards *A* and *B* and the front of the blank board.

The indicator 1 slides on a ½x1-in. strip nailed to the outer edge of board *B* with leather washers between the board and the stop to allow the guide of the indicator to work up and down. The gage shows at a glance the head water, tail water and effective head in feet.

Copperfield, Ore. W. T. KINGSLEY.

Clearances and "Safety First"

With the exception of high-voltage wiring comparatively little scientific analysis appears to have been given to problems of clearance in power and industrial plants; yet, here is an important field for study in relation to the safety movement as well as directly concerning efficient operation.

The spacing of equipment, widths of passages, minimum allowable distances between pipe lines, walls and galleries, the maximum height necessary for the safe and convenient handling of basement valves, connections for the replacement of pump parts—these and many other clearance factors affect the ultimate cost of service. Today we go largely by the designer's "educated guess" as to the necessary clearances in power stations, but the time is coming when the efficiency engineer will take this problem in hand. He will mass data on clearances, noting the approximate increase in the cost of building and structural members resulting from an added width of a foot here or a yard there, and will be equally keen in insisting upon a certain minimum spacing for safe and rapid operating movements.

It would, perhaps, be going too far to assert that this kind of analysis will result in the immediate standardization of such dimensions as the width of boiler-room aisles, clearance between the most exposed contact of an industrial-plant switchboard and the nearest generator or turbine bearing, the width of the mat in front of the remote-control panels of the operating gallery, or the distance between foundations of feed pumps. But on the one hand we have the natural desire of the operating man to "go the limit" on clearances, and on the other, the pressure of the plant owner to keep down the fixed charges.

From the operating standpoint there is nothing more desirable than plenty of elbow-room about a station, and it is better to err in this direction than in the narrow and usually crooked path of inadequate clearance; but as the economics of plant administration is studied more deeply, approximations in design are being scrutinized more and more critically. Many a plant engineer fails to receive even the minimum clearance to which he is entitled by sound engineering judgment, for the simple reason that when proposed changes in station layout are tentatively discussed in his presence, he does not think it the right time to speak about this particular point. There is no use in being so overjoyed at the prospect of having a new motor-generator set, a duplicate bank of transformers or a parallel steam line to a set of auxiliaries as to forget to ask, firmly and politely, for at least a stated minimum clearance where it means safety first.

Cambridge, Mass. H. S. KNOWLTON.

Motor-Driven Turbine Pumps

The charts were taken from a recording voltmeter and a recording pressure gage showing the effect of voltage regulation on the resulting pressure and delivery from

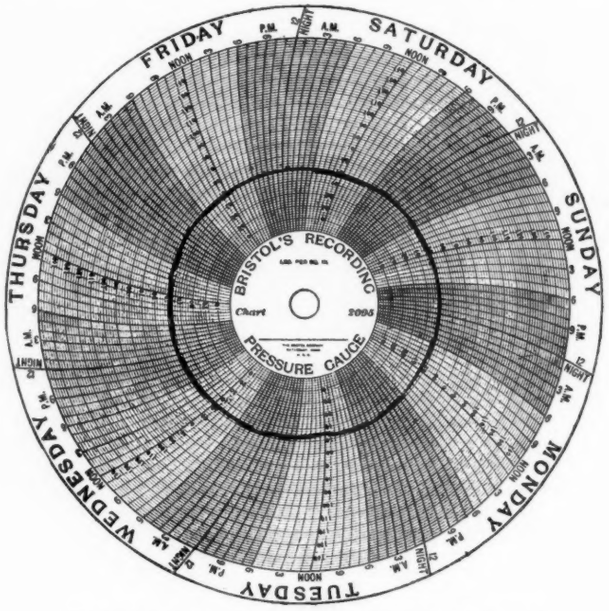


CHART FROM RECORDING PRESSURE GAGE

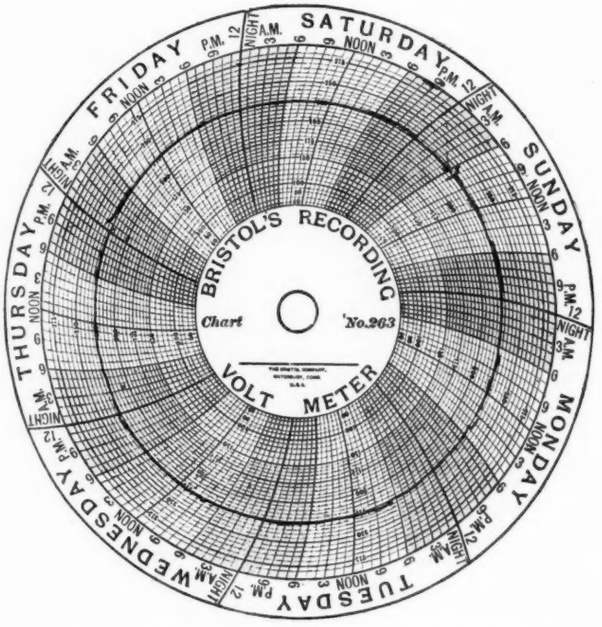


CHART TAKEN WITH RECORDING VOLTMETER

a two-stage 2,000,000-gal. vertical motor-driven turbine pump at a city pumping plant.

These charts may possibly be of interest to some readers of *Power* who are contemplating changing over to motor-drive for their pumping equipment.

Baltimore, Md. A. E. WALDEN.

Pounding Engines—In searching for the cause of the trouble do not attempt to remedy it too soon. If it is apparent that keying-up is required, do not key too tightly, and try to do it all at once, as the crankpin or crankshaft may be flat on one side and there is danger of getting a hot bearing or brasses.

The Hall of Records Test

An attempt to analyze the report made by the engineers of the Bureau of Municipal Research on the Hall of Records test, as reported in *Power* of Mar. 14, cannot be at all accurate, with the meager details afforded. I think there is enough given, however, on which to base a little study, and I have therefore made a few computations with the hope of drawing out further discussion and perhaps the detailed methods used by the engineers of the three parties to the test in arriving at their conclusions.

In looking over the report I find several discrepancies that I believe could be harmonized without much difficulty. One of the first of these is the very small allowance by Mr. Bolton for engine contribution to steam for heating, namely, 11,250,956 lb. I give his figures, as they were not includeed in the summary printed in *Power*, and will give my own computations in the same table, for convenience in comparison:

	Bolton	Bolton*	City Engineers*
Total steam	81,656,863	81,656,863	81,656,863
Deductions, Lb.:			
Engine exhaust	36,275,352	36,275,352	31,083,000
Clean drips	2,600,000	3,880,595	5,751,592
Feed-water heater	1,000,000	.....	.....
Auxiliary pumps	200,000	3,553,600	2,664,200
Exhaust-pipe condensation	200,000	.....	.....
Leakage	.....	.....	1,540,684
Totals	40,275,352	43,709,547	41,039,476
Net after making deductions.	41,381,511	37,947,316	40,617,387
Engine contribution to heating	11,250,956	26,195,843	22,736,315
Steam required with engines shut down	52,632,467	64,143,159	63,353,702
Equivalent coal, on basis of 7.9 lb. steam per lb. of coal, tons	3,330†	4,059†	4,009†
Coal saved with engines shut down, tons	1,837	1,108	1,158

*Computed by the writer on the basis of percentages given or deduced from the report under discussion, and explained later. †The coal actually used in test was 5,167 tons.

The allowance by the test engineers of 36,275,352 lb. of steam for the engines is 52.48 per cent. of all the exhaust steam made (69,116,887 lb.). Allowing this same percentage as engine contribution to the exhaust steam available for heating, after deducting the foul-drip loss and exhaust steam used for other purposes, 52.48 per cent. of 49,911,843 = 26,195,843, as given. Even if Mr. Bolton allowed that percentage on only the exhaust steam actually returned from the heating system (29,328,384 lb.), we would have 15,392,730 lb. instead of 11,250,956 as allowed by him. But this would not be right, as the engines get through with it before it is distributed to the roof stack, heating system, etc., and should be credited with their share of the total available exhaust, for if not furnished by the engines, it would have to be supplied by live steam either through the reducing valves or from the New York Steam Co.

A large percentage of the loss of steam (23,852,060 lb. or 44.85 per cent. of the total delivered to the heating system) is given as roof-stack loss and is simply the difference between the total supplied to the heating system and that actually returned. It was shown by the report to be greater in summer than in winter, because then all the steam in a noncondensing plant has to go outdoors, whereas in winter, while a larger total amount of steam must be generated because of the greater demand for light, much of the exhaust is called on for heating.

Incidentally, where there are hydraulic elevators already installed, it would seem that the back pressure on the engines could be materially reduced and that much steam saved in summer by cutting in the circulating water from the elevator pumps and using it as condensing water for the exhaust steam. Where the elevator load is comparatively large, the amount of water would doubtless be enough to avoid an objectionable rise in temperature.

Reverting to the comparative savings indicated in the table, the proportionate reduction of clean drips should, in my opinion, be based on the total steam raised rather than on that converted into exhaust, as doubtless each particular item of live-steam distribution suffers its proportionate clean-drip loss, and I so computed it. Yet this is a matter that could not be definitely figured without accurate knowledge, as it would depend largely on the arrangement of live-steam piping and covering.

Allowance for Feed-Water Heat

I really cannot see why Mr. Bolton makes any allowance for feed-water heat not wanted if the engines are shut down. Practically all the feed water is heated by exhaust, and he figures 1,000,000 lb., evidently live steam, for that, or roughly, 1¼ per cent. of all the steam made.

It seems also rather an insignificant matter to mention 200,000 lb. of exhaust-pipe condensation. Ordinarily one would not look for live-steam condensation in an exhaust pipe, yet this item of 200,000 lb. reduction of exhaust-pipe condensation would have no weight in the argument, as he uses it, unless it were considered as coming direct from the live steam and as a direct consequence of cutting out the engines. Certainly in summer there would be no live steam going to the exhaust stack, and in winter the only exhaust-pipe condensation from that source would be from the reducing valves, to help out in the heating; and if the engines were not running, even more live steam would be necessary for heating than was used in the test. Therefore it would appear that Mr. Bolton has used this item, even though very small, on the wrong side.

Analysis by Bureau Engineers

As to the conclusions of the engineers of the Bureau of Municipal Research, I fail to entirely grasp their logic or agree with their methods. Instead of computing the balancing losses of steam, as do the other parties to the test, they divide the engine output into three parts: (*H*) = exhaust steam used in the heating system; (*L*) = roof-stack loss (chargeable to the engines); (*D*) = foul-drip loss (chargeable to the engines). For this purpose they divide the year into two parts—(*a*) the period during which the roof-stack loss is less than the engine steam and (*b*) the period during which the engine steam is less than the roof-stack loss.

When the engines are shut down, (*L*) and (*D*) are wiped out, as the heating system calls for (*H*) only. "In case (*a*), when roof-stack loss is less than engine steam, (*L*) is known from the test figures and (*D*) can be readily computed, since the foul-drip loss percentage is known week by week, (L + D) therefore represents the saving due to shutting down the engines."

Case (*b*), when the engine steam is less than the roof-stack loss, represents summer and possibly some periods when the heating demand is very light, and then the engine steam is carried over into the column of steam saved.

The report contains a table of these amounts (not reproduced in *Power*) based on the test engineers' esti-

mate, by weeks for the year. In the heating season the engine steam is not considered saved, but only the roof-stack loss and the engine percentage of foul drips. In summer, when no steam is used for heating, neither the roof-stack loss nor the foul drips are considered saved, but the entire engine steam is carried over into the savings column, and the saving for the year is computed to be something over 25,000,000 lb. This is not very far from my own conclusion, as given, from the test engineer's estimate, but for some of the steps I see no warrant. Especially, I do not understand why they consider the whole of the roof-stack loss, when exhaust steam from other sources goes into that loss. In their discussion, as quoted, this is mentioned as "chargeable to the engines," but in the table the whole is used.

One reason for my interest in this matter is that in a new public building now under construction the question of street or city-made electricity has come up and, I believe, is not yet settled. It is intended to supply heat from another public building close by, with an additional boiler in the old building, and the question arose as to installing a lighting plant also in the old building, to light these two buildings, and in addition two or more other public buildings near-by, and utilize the exhaust for heating the two main buildings. The old building now has hydraulic elevators, but the question as to hydraulic or electric elevators for the new one has not yet been decided, so far as I know. It has been suggested that in a block plant the extra current for electric elevators in the new building would help out the day load and provide exhaust steam at a time when most needed.

Port Richmond, N. Y. AMZI T. ROGERS.

Lime on Leather Belts

Continuing the discussion of the use of lime on oily belts, its disastrous effect on leather is noticeable on a plasterer's shoes, How it burns and cracks them! It certainly removes the oil—like killing the fleas and the dog by the same means. Personally I prefer other means of restoring a belt to good working condition.

Spokane, Wash. WILLIS W. NELSON.

Preparing Boys To Be Engineers

Since September, 1914, the Stuyvesant Technical High School, of New York City, has adopted a course for the preparation of boys for the profession of engineering, which gives young men a splendid chance. This is known as the coöperative course, the fundamental principle of which is to give the students practical and theoretical work in unison. The pupils are sent to work in a private plant or one of the city's power plants—one-half working while the other half attend school, and each week the boys alternate. Once each week the instructor visits the plants where the boys are working.

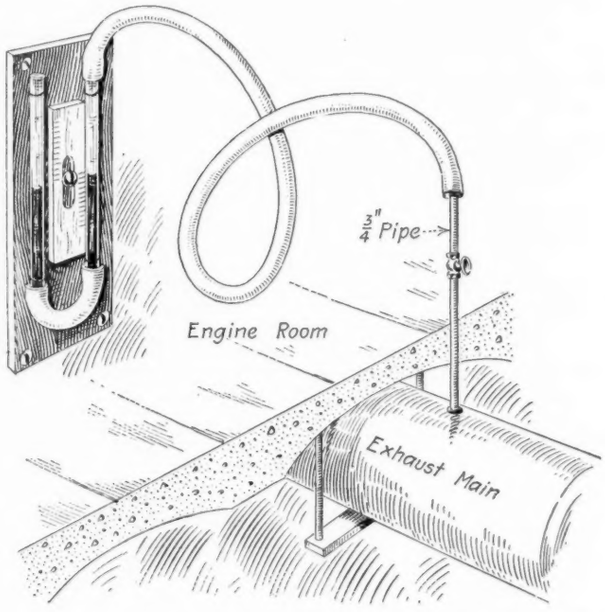
This engineering course of one year follows the regular three years of high school and subjects such as business English, machine-shop practice, mechanical and electrical laboratory practice, machine design and economics are taught. As a result of this instruction I am now employed at one of the best plants in the city, and I believe this method of teaching is the best ever introduced in the public schools for boys that cannot go to college.

New York City. JACK STROM.

Low-Reading Pressure Gage

There is always more or less doubt about the correctness of low-pressure gages, and the truth of our gage was seriously doubted. Tenants contended that they were not getting enough pressure to heat with, and I, that they were asking for too much pressure, as I knew pretty nearly what the back pressure was, although the gage did not always indicate correctly.

After trying several gages, I made the one shown in the illustration and there was no more argument. The cause



APPLICATION OF MERCURY-FILLED PRESSURE GAGE

of most of the trouble was found to be that some of the traps were airbound, and consequently there was poor circulation in the heating system. As this gage may save some other engineer the trouble of trying to convince some fellow (from Missouri) and settle a controversy, I pass it along.

It is made of two glass tubes (ordinary gage-glasses) and a piece of rubber tubing or by heating the glass and making a U-tube. Make an adjustable scale out of a piece of a rule or yardstick, or even a pine board ½ in. thick will answer the purpose. Fasten this with a screw to the backing to which the glass tubes are attached, mount the gage in any convenient place, and put mercury into the glass tube. The quantity of mercury and the length of the tube will depend on the back pressure to be carried, remembering that 1 in. of mercury will balance a pressure of 0.49 lb. A short time after turning on the pressure, there will be a column of water on the top of the mercury in the tube to which the steam line is connected, so that the scale must be readjusted to the zero mark. A valve is provided to shut off the pressure and disconnect the tubing at any time or to see that the adjustment for the zero mark is correct.

It is convenient to have the scale graduated in inches because 1 in. from the zero mark will represent roughly 1 lb. pressure—slightly less, as the actual pressure for 1 in. on the scale will be 0.98 lb., but close enough for practical purposes. J. A. MCGILLIVRAY.

Trenton, N. S., Canada.

Inquiries of General Interest

Double-Eccentric Engine—What is meant by a double-eccentric engine? E. A.

Engines known as double-eccentric engines are provided with one eccentric for operating the admission valves and another for operating the exhaust valves.

Over-All Efficiency of Electric Plant—What is the over-all efficiency of a steam-turbine plant using fuel oil of 18,500 B.t.u. per lb. for 300 kw.-hr. produced at the switchboard per 336-lb. barrel of oil? J. H. W.

The heat value per barrel of oil would be $18{,}500 \times 336 = 6{,}216{,}000$ B.t.u. One kilowatt-hour is equivalent to 3,412 B.t.u., and for the development of 300 kw.-hr. with 1 bbl. of the oil the over-all plant efficiency would be

$$\frac{3{,}412 \times 300}{6{,}216{,}000} \times 100 = 16.4 \text{ per cent.}$$

Increased Power of Chimney—What will be the percentage of increase in power of a brick stack 110 ft. high if, with the same size of flue, the height is increased to 150 ft.? W. T. S.

For the same temperature of flue gases the pressure, or force of the draft at the base of the stack, would be $\frac{150}{110}$, or 1.363, as much, and as the velocity of the gases would be $\sqrt{150} : \sqrt{110}$, or 12.247 : 10.488, the percentage of increase in power of the chimney would be

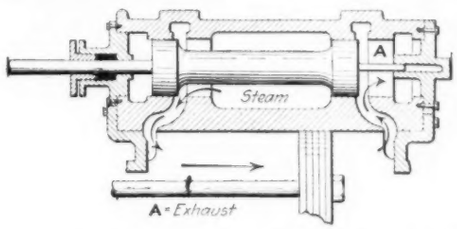
$$\frac{12.247 - 10.488}{10.488} \times 100 = 16.6 \text{ per cent.}$$

Safety of Closed Feed-Water Heaters—What tests should be made of the safety of closed feed-water heaters? C. M.

Closed feed-water heaters become weakened from the corrosive action of feed waters, and serious injuries by scalding have resulted from the unexpected rupture of the shells. To guard against accidents, the shell of a closed heater should be frequently subjected to a test pressure not less than 50 per cent. greater than the highest pressure possible for the discharge from the feed pump. Trials of the safety valve should also be made to determine its condition and the ampleness of its capacity for safely relieving excessive pressure when the feed pump is operating at its maximum.

Indirect Piston Valve—Is a piston valve that takes steam on the inside a direct or an indirect valve? J. H.

The terms "direct" and "indirect" are often used as synonymous with outside and inside admission, and when steam is



INDIRECT OR INSIDE ADMISSION PISTON VALVE

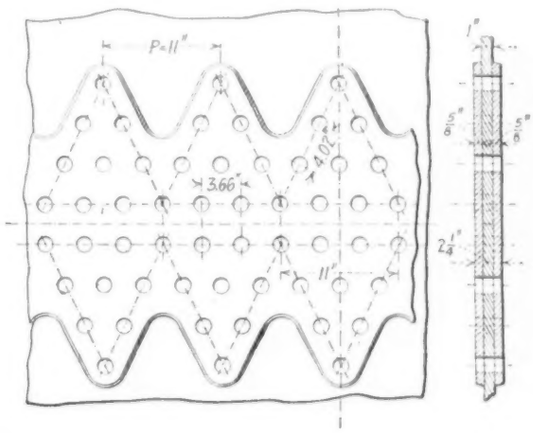
admitted at the inside edges of the valve, as shown in the sketch, the valve is said to be "indirect."

Loss of Power from Throttling Action of Steam Line—What loss of power is occasioned by 7 lb. drop of pressure in a steam line that delivers steam generated at a pressure of 100 lb. gage to a noncondensing Corliss engine? F. R.

The drop in pressure does not necessarily indicate a loss of energy, as the friction which causes the drop transforms the energy into heat that is employed in evaporating the moisture or in superheating the steam. The loss, if any, results from the actual difference of steam economy of the engine when supplied with steam at the reduced pressure as compared with the pressure carried on the boiler. Under ordinary conditions the difference would not be practically discernible, and with a load too small for the engine, the reduction of initial pressure might even be advantageous to the operating economy of the engine. In any event, the economy of supplying the engine with steam at the present boiler pressure carried can be realized by increasing the boiler pressure sufficiently for that purpose.

Efficiency of Double-Shear Boiler Joint—What would be the efficiency and working pressure, with a factor of safety of 6, for the butt and double-strap joint shown by the sketch, where the tensile strength of plate is 55,000 lb. per sq.in.; thickness of plate, 1 in.; thickness of butt straps, ⅝ in.; pitch of rivets of outer row, 11 in.; diameter of rivets after driving, 1⅛ or 1.125 in.; shearing strength of rivets, double shear, 78,000 lb.; and crushing strength of plate, 95,000 lb.? G. K.

All rivets would be in double shear, each offering a resistance of $78{,}000 \times (1.125)^2 \times 0.7854 = 77{,}532$ lb. The crushing strength of the main plate in front of a rivet would be $95{,}000 \times 1.125 \times 1 = 106{,}875$ lb., and the combined crushing



BUTT AND DOUBLE-STRAP JOINT WITH ALL RIVETS IN DOUBLE SHEAR

strength of two ⅝ butt straps would be even greater, hence the crushing resistance of the plates can be neglected.

Since a rivet hole removes a section 1⅛ in. wide, each rivet in any row weakens the plate section through that row by $1.125 \times 1 \times 55{,}000 = 61{,}875$ lb. This is less than the shearing strength for a single rivet. Hence in consideration of failure of the plate through any row of rivets, excepting the outer row, it is seen that the resistance of at least as many rivets is added in shear as there are holes in the row, and therefore the combined shearing strength of rivets and tensile strength of plate through any row of rivets, excepting the outer row, could not be a method of joint failure.

For a unit length of joint equal to P, or 11 in. pitch of rivets of the outer row:

A. Strength of solid plate $= 11 \times 1 \times 55{,}000 = 605{,}000$ lb.

B. Strength of plate between rivet holes in the outer row $= [(11 - 1.125) \times 1] \times 55{,}000 = 543{,}125$ lb.

C. Strength of 9 rivets in double shear $= 77{,}532 \times 9 = 697{,}788$ lb.

D. Strength of butt straps between rivet holes in the third or fourth row $= [11 - (3 \times 1.125)] \times \frac{5}{8} \times 2 \times 55{,}000 = 524{,}218$ lb.

As the strength of the joint would depend on consideration D, the efficiency of the joint would be

$$\frac{D}{A} = \frac{524{,}218}{605{,}000} = 0.866$$

As 11 in. length of the joint would have a strength of 524,218 lb., used as the longitudinal joint of a cylindrical shell 90 in. dia. with a factor of safety of 6, the joint would have sufficient strength for a working pressure of $\frac{524{,}218}{11 \times 45 \times 6} = 176.5$ lb. per sq.in.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Mechanical Engineers Meet at New Orleans

The spring meeting of the American Society of Mechanical Engineers was held Apr. 11-14 at New Orleans, the early date being occasioned by the place selected for the meeting. The Louisiana Engineering Society jointly with the local membership of the American Society of Civil Engineers and the American Society of Mechanical Engineers acted as host to the visitors.

On the way down the specials from the East and the West stopped over for a day at Birmingham, Ala., where the members were the guests of the newly formed local section. Visits were made to the Republic Iron and Steel Co., the Tennessee Coal, Iron and Railroad Co. and the American Steel and Wire Co. A barbecue was served at Bayview. In the evening a dinner was given at the Tutwiler Hotel, at which addresses were made by City Commissioner John R. Hornady; W. C. Radcliff, of the chamber of commerce; F. H. Crockard, vice-president and general manager of the Tennessee Coal, Iron and Railroad Co.; and on behalf of the society by Past-President W. F. M. Goss, Secretary Rice and Charles Whiting Baker. The toastmaster was R. E. Brakeman.

Arriving at New Orleans on Tuesday morning, headquarters were established at the Grunewald and the afternoon was spent in visiting the French quarter. An informal reception was held in the evening.

The professional sessions opened on Wednesday morning with a paper on "Organizing for Industrial Preparedness," by Spencer Miller, the society's representative on the United States Naval Consulting Board. The speaker emphasized the importance of the industrial census of the country to be undertaken by representatives of the five national engineering societies at the invitation of President Wilson. Not only will this determine where munitions, including supplies of all kinds, can be obtained, but also how rapidly they can be produced, to what extent America is independent of other countries for raw materials and manufactured products, for what kind of munitions we have ample manufacturing facilities, and wherein means must be provided for any deficiency.

The afternoon was spent in an excursion about the harbor, and in the evening an address was delivered by W. B. Thompson, commissioner of public works of the City of New Orleans. Following this there was further discussion of Mr. Miller's paper, which lasted till after 11 o'clock.

The papers read on Tuesday morning were: "Capacity and Economy of Multiple Evaporators," by E. W. Kerr; "Mechanical Equipment Used in the Port of New Orleans," by William von Phul; and "The Evolution of Low-Lift Pumping Plants in the Gulf Coast Country," by W. B. Gregory. The last paper outlined the part that pumping machinery has had in the development of the City of New Orleans and in the reclamation of the fertile wet prairie lands of Louisiana and Texas. Some typical pumping plants were described, and reports of tests conducted by the author were included.

In the afternoon the visitors were entertained at the New Orleans Country Club and in the evening a reception and dance was given at the Grunewald.

On Friday morning the professional papers were presented at two simultaneous sessions. These included "Establishing a Standard of Measurement for Natural Gas in Large Quantities," by Francis P. Fisher; "Deviation of Natural Gas from Boyle's Law," by R. F. Earhart and S. S. Wyer; "Some Experiments on Water Flow Through Pipe Orifices," by Horace Judd; "Dynamic Balance," by N. W. Akimoff; "The Measurement of Viscosity and a New Form of Viscosimeter," by H. C. Hayes and G. W. Lewis, and "The Transmission of Heat in Boilers," by E. R. Hedrick and E. A. Fessenden.

The paper by Messrs. Earhart and Wyer was based on tests made by the authors at the Ohio State University. The data obtained showed that: (1) All the observed deviations of natural gas from Boyle's law are in one direction—in favor of the buying company where gas is measured under high-pressure conditions; (2) the different gases have marked peculiarities and marked differences of deviation; (3) there is no direct relationship between the deviation and ethane content; (4) the direct application of Boyle's law to high-pressure natural-gas measuring problems gives only an exceedingly rough approximation.

In the paper on "The Transmission of Heat in Boilers," the authors, using data furnished by William Kent, the Pennsylvania Railroad, the Babcock & Wilcox Co., and data from old French experiments, found difficulty in checking the results of their own experiments and the foregoing data with theories commonly proposed for the transmission of heat into boilers. The assumption is made that the quantity of heat lost by a given weight of gas falls off as the gas passes down the pipe, in accordance with the ordinary damping law. The paper is replete with curves and tables. It will not be abstracted in "Power" owing to its highly technical character and length, making a full reprint necessary to an adequate understanding of the authors' purpose.

Friday afternoon was spent in an excursion to reclaimed lands near New Orleans to inspect tracts that have been restored and turned to useful purposes as well as some drainage pumping plants.

Although this concluded the official program, many of the guests remained over Saturday to inspect some of the industrial plants and engineering undertakings in the vicinity.

Co-operation in Engineering Societies

About a year ago, at the spring meeting of the American Society of Mechanical Engineers at Buffalo, a dozen men met informally and talked over the desirability of a closer co-operation between the various engineering societies of the country. To keep the question alive it was concluded to form a volunteer organization. Representations were made to the various national, state and local associations of the country, with the request that each send a representative to a general conference to discuss how coöperation might best be brought about. On Apr. 13 and 14 this conference was held in Chicago, in the rooms of the Western Society of Engineers, with Prof. F. H. Newell, of the University of Illinois, as chairman. Accredited delegates or individuals from 42 different societies—local, state and national—were present.

At the first session, Thursday morning, three-minute talks by each of the representatives were called for, beginning with the delegates from the large national societies. In these various talks the representatives spoke of the work that was being done by the societies they represented. The delegates from Detroit, Philadelphia, St. Paul, St. Louis, Cleveland and other cities were exceptionally interesting, as in each of these cities the local sections of the national societies or a number of different engineering societies were coöperating to the benefit of all concerned. Those who had seen the results of coöperative work at home were enthusiastic and felt that national coöperation was badly needed. In fact, all recognized the desirability of coöperation, but the representatives of the large national societies did not approve of a new organization. They did feel, however, that the local sections should get together and unite on matters of common good. Only in this way could the movement be started without antagonizing the older and well-established societies, which had the prestige, the organization and the money to insure success to a movement of this kind. It could hardly be expected that they would place themselves subordinate to a new association.

Following the roll call Paul Hansen, chief engineer of the Illinois State Board of Health, presented a paper recommending two engineering organizations—one to represent state and sectional societies and the other to represent the national societies. In the state association all efforts to maintain a professional classification should be abandoned; it should be thrown open to all engineers and surveyors of good moral character. A union of these state societies in a national organization would greatly facilitate giving nation-wide activity to any movement of common interest to all.

Willard Beahan, from the Cleveland branch of the American Society of Civil Engineers, favored coöperation among the local sections of the large national societies. All should belong to a local city society. With headquarters in one place

they would have an opportunity to become better acquainted and, as a larger body, would have more influinece in engineering affairs. Engineers should try to be more human. Too many are men of the cloister and not men of the camp. They should get together even if only at a dinner or ball game. Learn what is being done by one another and become acquainted with the needs and interests of other engineers out of their particular sphere. In his opinion these city organizations should discuss matters of interest with similar organizations in other cities without working through the home offices of the various societies going to make up the local body. The speaker was a great believer in team work and thought that the coöperation being discussed at the present meeeting was going to help put things on the right basis.

At the afternoon session there were a number of interesting talks. Lewis R. Ferguson told how coöperation among the various societies had been effected in Philadelphia. A. W. Hoffman, of Chicago, spoke on the German Society of Engineers, a national body with a council of delegates from district organizations. The districts were practically autonomous, but matters of general interest were referred to a national board and executive council. These various organizations, however, were on the same professional plane and not so diversified in character as the engineering organizations in this country.

METHODS IN SEVERAL CITIES

H. F. Nichols, secretary of the Chicago section of the American Institute of Mining Engineers, spoke of the cooperative efforts that had recently been made in that city. The working of the engineers' club of St. Louis was explained by J. W. Woermann. H. C. Gardner outlined the work of the American Society of Mechanical Engineers, and a paper by Peter Junkersfeld, of the Commonwealth Edison Co., took up briefly the work of the American Institute of Electrical Engineers and its 86 local sections and branches. Dean J. F. Hayford, of Northwestern University, representing the Society for the Promotion of Engineering Education, spoke briefly on educational work and assured the convention that coöperation could be expected from his society.

On Thursday evening C. E. Drayer, secretary of the Cleveland Engineering Society and also secretary of the committee on engineering coöperation, gave an unusually interesting address on publicity work which had been carried on in Cleveland, outlining the kind of material that would be of interest to the public and how it should be prepared for the press. The balance of the evening was devoted to the presentation of resolutions to be passed upon the following day.

At the Friday morning session Arthur Kneisel, secretary of the American Association of Engineers, defined an engineering employment agency, and gave a general talk on the employment of the engineer. Fred G. Simmons spoke of the good work that had been done in Wisconsin in the way of coöperation between the various engineering societies. He believed in coöperation between all men interested in engineering work. That is, there should be a state association including salesmen and manufacturers as well as engineers. He was a great believer in standing committees and thought that all work relating to the bettering of standard practice, publicity or legislation could be accomplished best by standing committees, whose reports were thoroughly discussed at annual conventions.

CO-OPERATIVE WORK IN ST. PAUL

Coöperative work in St. Paul, as explained by George H. Herrold, proved to be of exceptional interest. He enumerated the various ways in which coöperation had been brought about and spoke of the gratifying results that had been obtained already in civic affairs and of the influence the engineers had on the state legislature. The work of the American Society of Heating and Ventilating Engineers and of its various sections was discussed briefly by John F. Hale. Dean A. A. Potter, of Kansas, showed the desirability of coöperative effort toward securing appropriations to carry on the work at the engineering experiment stations of the land-grant engineering colleges. J. W. Woermann gave an interesting account of the coöperative journal in which the proceedings of a number of societies had been published and from which each society got the benefit of all material presented by the other societies. After 35 years of coöperation disintegration finally has been brought about by local pride. As each association increased in numbers and became more prosperous, it desired a bulletin of its own. One association after another withdrew until the joint effort had to be given up. The results did not hold out much encouragement for a new movement along these lines.

Gardner S. Williams, of Ann Arbor, Mich., favored consolidation rather than coöperation. In his opinion there should be one association representing the great body of engineers and not the engineering societies. Representatives could be selected to form a central governing board, in much the same way that Senators or Representatives are chosen to represent the various states in the Federal Government.

At the session Friday afternoon H. J. Burt delivered an address on the "Duties of the Engineering Society in Legislative Matters." A. J. Himes, of Cleveland, spoke on publicity, the title of his address being "The Public and the Engineering Profession."

An address by Isham Randolph so ably expressed the spirit of the conference that the concluding paragraph was adopted as an expression of the committee as a whole, to show the intent of the meeting and to allay any fears that a new association might be formed. This paragraph follows:

Let us have a central organization—call it what you will—which has no authority to command, but which has ears to hear and a voice to be heard, and let those ears be open to every plea or promise of common good, and let that voice go out to all affiliated bodies carrying this plea or this promise for the common good, and let us come together at least once a year and feel that touch of nature which makes the whole world kin, and growing out of that kinship let us consider and do those helpful things which will bless our comrades and overflow with helpfulness to our country and our kind.

The following resolution was adopted at the conference:

Whereas, The rapid increase in engineering activity of recent years has given rise to many problems vitally affecting the practice of engineering; and

Whereas, Existing agencies through lack of proper correlation appear inadequate for the solution of these problems and in order that the resources of the profession may be made available for the most useful service of the nation, state and municipality and that the practice of engineering may be rendered more efficient and less burdensome in those places where its development has been most difficult; and

Whereas, It is the sense of the second conference on engineering coöperation, representing societies, national, state and local, and comprising various branches of engineering, that these ends may be attained through a closer association and coöperation of engineering societies: Be it

Resolved, That there is hereby established a subcommittee, with Prof. F. H. Newell as chairman and four other members to be selected by him, with instructions to prepare a plan for forwarding coöperation upon matters of general interest to the engineering profession among engineering societies, such plan of organization to be presented for formal consideration at a third conference on engineering coöperation to be called by the subcommittee at such time and place as may seem to it desirable; be it

Resolved, That the several organizations represented at this conference should be permitted to assist in defraying the expenses of the committee of engineering coöperation and that the subcommittee should be requested to present to each of the societies represented an estimate of probable expenditures, including clerical service, together with recommendations for equitable prorating; be it further

Resolved, That this conference express its high sense of appreciation for the courtesies and hospitality extended by the Western Society of Engineers, subdivision 63 of the Chicago Association of Commerce and the Chicago Engineers Club, and hearty thanks therefor are hereby expressed.

The resolution was unanimously adopted and the subcommittee will call a third conference as soon as it has some definite plans to offer. Although it was the consensus of opinion at the present conference that engineers and the various societies should pay more attention to the social element, legislation, publicity and to coöperative effort, no one seemed to have a clearly defined plan of procedure acceptable to all. The new subcommittee will have the advantage of the general expression of opinion, however, and at the next conference should have something specific to offer.

The Question of Drive for Station Auxiliaries

In his presidential address to the Institution of Engineers and Shipbuilders in Scotland, W. W. Lackie said that the following alternatives for the driving of auxiliaries are available: Separate steam engines or turbines, alternating-current motors, continuous-current motors and power obtained from the main turbine. There is a considerable difference of opinion as to which is the best method.

For many years it has been a fashion to use electric motors for driving auxiliaries, but recently it has been shown that when a failure or interruption of supply has occurred or where a plant had to be started up quickly in case of a sudden demand, there was delay in getting the auxiliary plant started, owing to the means of driving it having also failed or being deficient. The supply of electric energy to the motors driving the auxiliary plant was obtained from the main generators, either direct or from the main busbars at the station. A stand-by supply of energy may be obtained from a battery, so long as the auxiliaries are small, but when we have to consider 50,000- to 100,000-kw. generating stations and the auxiliary plant amounts to between 5 and 7 per cent. of the whole station capacity, it means from 2,500 to 7,000 kw., and for this a battery stand-by is quite out of the question.

Continuity of supply is of first importance. No matter how cheap a supply may be, if it is unreliable and subject to frequent and continuous interruptions, it will fail to attract the large power user. A great point of importance is to devise ways and means to reduce to a minimum the extent and duration of interruptions when these do occur in spite of every precaution for their prevention. The engineer in charge, faced with an interruption of supply, has his hands full in getting machinery into commission to take the place of the set or sets that have failed, and if he is called upon to tackle a failure in his auxiliary plant at the same time, the duration of the interruption of supply will probably be doubled. An elementary but most necessary precaution, therefore, in reducing possible failure to a minimum is to see that the auxiliaries are not dependent on the main generators for their supply of power.

In many power stations recently erected the auxiliaries are directly driven by independent steam turbines. This makes a very desirable combination, as the drive of the auxiliaries is self-contained in every respect except as regards the supply of steam. On two 9000-hp. sets in the generating station of the Glasgow Corporation a small steam turbine of 200 hp. drives the circulating air and condensate pumps, together with a small force pump, all on one shaft, and a very reliable and simple combination of auxiliaries is thus provided. A drawback to the arrangement is that the most efficient speeds of the various pumps may not be the same. It is absolutely necessary for the efficient running of the plant that all exhaust steam should be collected and used. These small steam turbines are run noncondensing, and the exhaust is used for heating the condensate from the main turbine. It is expensive and complicated to drive each auxiliary by a steam turbine, owing to the necessity of running long lengths of steam and exhaust piping to, say, fans, stokers and coal-conveyors.

In the new generating station to be erected at Dalmarnock it has been decided to drive the auxiliary plant electrically. The source of supply will, however, be quite separate from the main busbars and will consist of turbo-alternators generating energy at 440 volts alternating current at 25 cycles per second. This decision has been arrived at for several reasons. The level of the Clyde from which the condensing water is to be taken is 20 ft. below the condenser floor level. This means that the main circulating pumps will be in a pit, and an electric-motor drive is the only one suitable. The air and circulating pumps will be driven by separate motors. The induced-draft fans will be on the third floor of the boiler house, and if they were driven by steam long stretches of steam and exhaust piping would be necessary. The novel features in connection with the design of the Dalmarnock works, which are departures from standard practice, are as follows:

The auxiliaries are all driven with three-phase alternating-current motors, the energy for these motors being obtained, as already stated, from separate three-phase turbo-alternators, the exhaust of which will be used to heat the condensate from the main turbine. This means that this condensate is to be used as the circulating water for the condensers of the auxiliary plant. The exhaust steam from the auxiliary turbine will raise the temperature of the condensate as circulating water from 80 to 140 deg. Fahr., after which it will be passed to the hotwell and, later, through an economizer. As the load on the auxiliary turbine, however, is likely to remain fairly constant, while the load, and therefore the condensate from the main turbine, will vary, the condenser of the auxiliary turbine will have a second set of tubes through which river water can be circulated. The amount of river water will be automatically regulated by the quantity of condensate coming from the main turbine. A certain amount of heat will be lost in raising the temperature of the circulating water taken from the river under other than full-load conditions. The auxiliary turbines can exhaust to atmosphere if any mishap takes place to their condensing plants. The auxiliary motors can be driven at odd times from the station busbars through a static transformer.

A Fatal Shrink Fit

By F. G. Flickinger

Recently a local machinist met sudden death in a manner that may serve as a warning to others engaged on similar work. It was desired to fit a new piston rod to a cast-iron piston head for a 16x14-in. simple high-speed engine. The piston was of the ordinary hollow-cored variety, 5¼ in. thick and divided into six ribbed compartments. Each section had screwed into it a plug that was afterward sawed off, the holes probably having been used to remove the core.

To get a shrink fit, the piston was heated outside over a fire to the desired temperature, it being intended to drive the piston rod to a fit in the taper of the piston. When all was ready to do this and four men were standing close by, one man kneeled to turn over the piston. Just as he did this, it let go with a loud report, one piece tearing off the whole side of his face, another breaking an arm and one taking off part of his hand. Another man had his arm and finger cut, but not seriously. The other two were only badly shaken up.

There must have been some water inside the piston, but just how it got there is not certain. I believe that turning over the piston was the last straw, for no doubt the piece was unevenly heated. Perhaps the small amount of water, as it hit the hotter surface, flashed into steam and added just the pressure needed to rupture the casting. Whatever the cause of the accident, the experience was costly and shows that similar jobs should be handled with the greatest care.—"American Machinist."

Split Boiler Tube Kills One, Injures Five

On Mar. 29 in the Beaumont plant of the Polar Wave Ice and Fuel Co., St. Louis, Mo., a boiler tube of the Heine boiler No. 1 split, causing the injury of six men, of whom one died in the hospital. The split was 13 in. long and occurred in a tube 18 in. from the rear water-leg in the sixth row from the bottom. The position of the boiler was such that water and steam blowing out from the combustion-chamber door in the rear and from the furnace door completely cut off the only exit from the boiler room, except by a 50-ft. ladder leading to the roof.

The efforts on the part of the five men, who were working in front of Nos. 2 and 3 boilers, to leave by the ladder were unfortunate for them, since the higher they went the more intense was the heat, due to the accumulated steam. Two of these men, while on the ladder, were overcome and fell back to the floor, one of them breaking both ankles in the fall. If the men had kept to the lowest part of the boiler room instead of striving to leave the room by the ladder, they probably would have got away without serious burns. The most seriously injured man was the one working at the back of No. 3 boiler. The lower portion of his body was so badly scalded, evidently during his efforts to reach the exit at the rear of No. 1 boiler, that he died later.

ENGINEERING AFFAIRS

Master Boiler Makers' Convention—The tenth annual convention of the Master Boiler Makers' Association will be held at the Hollenden Hotel, Cleveland, Ohio, May 23-26, 1916.

Pratt Institute Exhibition—The twenty-ninth annual exhibition of the work of the students in each of the five schools of Pratt Institute will be held Apr. 27 to 29, from 2 to 10 p.m. on the first two days and from 10 a.m. to 5 p.m. the last day.

Ohio State University Inspection Trip—The fourth-year students in mechanical and electrical engineering of the Ohio State University under the leadership of four instructors have just completed an interesting inspection trip. Two days were spent in Cleveland, two in Pittsburgh, two at Niagara Falls and one in Buffalo. In addition to a bulletin containing a very complete itinerary, each student was provided with a booklet on "Things to Be Observed and Noted," showing them what to look for while making the trip. The thoroughness with which preparations were made for the trip made it more than usually productive of real benefit to the students.

New York State Industrial Preparedness Committee, the Naval Consulting Board of the United States, New York State Section, appointed by the Secretary of the Navy Daniels, met at a luncheon given Apr. 14, at the Bankers' Club, New York, by J. G. White, president of J. G. White & Co., Inc., and formally organized for active operation. The Industrial Preparedness Committee of the Naval Consulting Board, of which H. E. Coffin, the well-known automobile engineer, is chairman, has undertaken an exhaustive census of the industries in the United States to determine what way and to what extent our various manufacturing plants are equipped to be of service to the Government in time of war. This census is to have the coöperation of each of the national engineering societies, and to insure their coöperation each society has a representative

on the various state boards. At the organization meeting J. G. White, representative of the American Society of Civil Engineers, was elected chairman of the New York State board. The other members are: Charles F. Rand, Spanish-American Iron Co., American Institute of Mining Engineers; W. H. Marshall, president, American Locomotive Co., American Society of Mechanical Engineers; Dr. T. B. Wagner, Corn Products Refining Co., American Chemical Society, and William McClellan, American Institute of Electrical Engineers.

PERSONALS

F. D. Horton, lately manager of the Pleasant Hill Electric Light and Power Co.'s plant, Pleasant Hill, Mo., has taken a position with the Thermal Efficiency Co., Kansas City, Mo.

John H. Lucas has been appointed president of the new Kansas City Light and Power Co., Kansas City, Mo. He resigned as general counsel for the local street-railway company to take the new position.

J. W. Bivins, Jr., has been promoted to the position of manager of the Cordele Electric Co., Cordele, Ga. He has been in the employ of the owner of the plant, the Southern Utilities Co., since it took over the property three years ago.

C. G. Childers, formerly manager of the new business department of the Gadsden, Alabama City & Attalla Street Railway Co., has resigned to go with the Alabama Power Co., at Birmingham, as special representative of the general and operating managers.

A. H. Grimsley, for the past year chief engineer of the Virginia-Western Power Co., was appointed general manager of the company, Feb. 1. The general offices are at Clifton Forge, Va. Mr. Grimsley was formerly with the West Virginia Water and Electric Co., at Charleston, W. Va.

BOOKS RECEIVED

COAL, ITS ECONOMICAL AND SMOKELESS COMBUSTION. By James F. Cosgrove. Technical-Book Publishing Co., Philadelphia, Penn. Cloth; 5½x8½ in.; 273 pages; 33 illustrations; tables. Price, $3.

CENTRAL STATION MANAGEMENT. By H. C. Cushing, Jr. and Newton Harrison. D. Van Nostrand Co., New York. Cloth; 5x7¾ in.; 397 pages. Price, $2.

MISCELLANEOUS NEWS

Marine Boiler Tests Modified—An amendment to the rules and regulations of the United States Steamboat Inspection Service modifies the provision for the required tensile strength of a test piece in connection with the stays or braces used in marine boilers. The new provision is that when the tensile strength of the test piece is more than 63,000 lb. per sq.in. of section each test piece that has been reduced in size shall show an elongation of at least 26 per cent. in 2 in. The former figure for the tensile strength was 66,000 lb.

Minneapolis Interested in Smoke Abatement—Osborn Monnett, formerly chief smoke inspector of Chicago, spoke on methods to the smoke-prevention committee of the Civic and Commerce Association at the Minneapolis Athletic Club, Apr. 6. "The most successful method of abating the smoke nuisance," said Mr. Monnett, "is to insist by ordinance regulation, backed up by your inspector, that smoke-prevention devices be installed in all new and remodeled plants." Walter Thorp is chairman of the association's smoke-prevention committee. The City Council has authorized employment of a smoke inspector for Minneapolis at an annual salary of $2,000. The position is to be filled by civil-service examination.

Baltimore Asks Boiler Bids—The Harbor Board of Baltimore is preparing plans and specifications for four large marine boilers for the steamboat "Annapolis." These boilers will be of 12 ft. inside diameter of shell by 11 ft. long over heads, built in accordance with the rules of the United States Inspection Service for steam boilers, with a pressure of 80 lb. Each boiler will have three Morrison suspension furnaces (or equal) 38 in. inside diameter by ⅜ in. thick and contain 60 sq.ft. of grate surface in each boiler, or 240 sq.ft. in the four boilers. Each boiler is to have 190 standard-gage 3-in. tubes furnished with the necessary manholes and stays, and to be fitted with a black-iron dry pipe 6 in. diameter and also with a superheater. Plans and specifications are being prepared, an advertisement for bids will be issued within the next week or ten days and bids will be received about the middle of May. The Harbor Board is anxious to get prompt delivery.

Classified Ads

Positions Wanted
Positions Open
Civil Service Work
Employment Agencies
Labor Bureaus
Business Opportunities
For Sale
Wanted
Agents and Salesmen
Contract Work
Miscellaneous
Educational
Books
Proposals

RATES: Positions Wanted, 3 cents a word, minimum charge 50 cents an insertion, payable in advance. Other advertisements, 5 cents a word, minimum charge $1.00. Count 4 words for blind address care of our New York or Chicago offices. Advertisements for bids $3.60 an inch.

ANSWERS addressed to us at 10th Ave. and 36th St., New York or 1144 Monadnock Block, Chicago will be forwarded without charge (excepting circulars or similar literature).

IMPORTANT: Original letters of recommendation or other papers of value should not be enclosed to unknown correspondents—send copies. Advertisers' names will not be furnished under any circumstances. Copy received until 10 A.M. Tuesday for following Tuesday's issue. P

POSITIONS OPEN

Canada

TWO MECHANICAL ENGINEERING DRAFTSMEN wanted; should have from six to eight years' experience designing. Apply by letter, stating qualifications and salary expected. The Canadian Copper Co., Copper Cliff, Ont.

Massachusetts

DRAFTSMEN wanted, experienced mechanical and electrical men by a large manufacturing concern in the East. Apply, stating age, education, experience and salary expected by addressing "Chief Draftsman," P777—Power.

Michigan

ADVERTISING MANAGER for old-established Detroit concern, in steam specialty line; man with technical training preferred, but must have experience in technical advertising; detail your experience, giving names of concerns, state age, whether married or single, salary expected, and how soon you could report for work; all communications strictly confidential. P775—Power.

New Jersey

AN ENGINEER wanted in the power plant of a large factory in New Jersey; must have experience in the operation of compound Corliss engines and be familiar with a.-c. and d.-c. current as well as the handling of switchboards, motors, etc.; he should also be thoroughly familiar with boiler-house practice and should have machine-shop experience; must be willing to work either on a day or a night shift; this position will be open around the first of June; a good opportunity at good pay for the right man. Address, stating age, married or single, experience, references, salary expected, and other particulars to P766—Power.

New York

OPERATING ENGINEER for central station plant in New York State; middle-aged man, experienced in operation of high-pressure boilers, steam turbines and plant auxiliaries; must be qualified to perform duties of chief engineer if required; give details of experience. P773—Power.

Pennsylvania

PRACTICAL MECHANIC wanted to take charge of repairs and upkeep of engines; state age, experience and wages expected in reply. P772—Power.

SEVERAL FIRST-CLASS DRAFTSMEN wanted at once, of general mill and blast furnace experience; state age, experience, present salary and salary wanted in first letter; also when available; central location, Pittsburgh. P687—Power.

SEVERAL DRAFTSMEN wanted at once, experienced in power plant and general piping work; state age, experience, present salary and salary wanted in first letter; also when available; central location, Pittsburgh. P688—Power.

West Virginia

ENGINEER wanted by a coal-mining company, located in West Virginia, to operate a 2,300-kw. power plant during the day shift; must be able to take full charge of the engine room, do repairs and keep all machinery in first-class condition; plant contains steam engines and turbines, a.c. and d.c. generators; married man preferred; in first letter give experience, references, salary wanted and when can be ready to start work. P774—Power.

Wyoming

YOUNG ENGINEER, now chief of large Diesel engine plant, desires change of location about June 1; competent to take charge of large steam, gas or oil engine plants; well versed in modern fuel combustion practice, electricity, mechanics, systematic upkeep and management of public utility or industrial power plants; Central States preferred. PW776—Power, Chicago.

Employment Agencies

CORRESPONDENT

THE UNDERSIGNED plans and conducts correspondence for positions in technical, manufacturing and professional lines; $2500 to $15,000 men exclusively; complete privacy assured; no commission charged—only service fee and postage. Send name and address only, in confidence, for prefatory details. R. W. Bixby (established 1910), P1 Niagara Square, Buffalo, N. Y.

POSITIONS WANTED

Canada

ERECTING ENGINEER wants position to take charge of erection, installation and maintenance of steam turbine plant, both steam and electrical ends; have held same position on large turbine station; 35 years of age; 14 years' experience. PW781—Power.

Connecticut

CHIEF ENGINEER open for position; 20 years' experience in large plants; highest efficiency assured; strictly temperate; best of reference. PW770—Power.

Illinois

ENGINEER WISHES POSITION as chief in small plant or assistant in large plant; 12 years' experience; A-1 references; will go anywhere. PW767—Power, Chicago.

ASSISTANT ENGINEER, oiler, head fireman or water tender; have had 12 years' experience as fireman and on other work in medium-size water and light plant; practical man; age 34, single; good references. PW780—Power, Chicago.

New Jersey

GAS PRODUCER ENGINEER with extensive experience on gas producer and oil engines; familiar with air compressors, ice machines, A. C. and D. C. generators; can get results; will go anywhere. PW778—Power.

New York

MECHANICAL DRAFTSMAN with technical training wishes position with chance for advancement. PW779—Power.

Virginia

BOILER SUPERINTENDENT and combustion engineer open for position; can handle any size or kind; prefer South or Western location. PW763—Power.

BUSINESS OPPORTUNITIES

PRIVATE OFFICE AND DRAFTING FACILITIES to sublet by established architects; central location; low cost. BO769—Power.

WANTED

MANUFACTURER wants either patented or patentable ideas on boiler and engine room specialties; cash or royalty basis. W676—Power.

AGENTS AND SALESMEN

REPRESENTATIVES for a new type of a thoroughly established and successful steam specialty; state experience and territory covered. W629—Power, Chicago.

HIGH-GRADE STEAM SPECIALTY SALESMAN, five years' experience with present firm; seeks connection with reliable firm; Philadelphia territory preferred. W768—Power.

AGENTS handling engine and boiler room specialties, in every section, for side line, paying large commissions. Give experience, lines carried and territory covered. W390—Power.

A LIVE POWER-PLANT SPECIALTY SALESMAN who can qualify will have an opportunity to join the sales force of a well known manufacturer on a commission proposition, offering extraordinary returns. Send details to W732—Power, Chicago.

A CENTRIFUGAL PUMP SALESMAN wanted in our Chicago office to cover certain parts of that territory; we want a young live wire; one who has sold pumps and has had real experience; a mechanical engineer preferred; preferably one familiar with the Chicago territory; if you have not had actual experience, please do not apply. Lea-Courtenay Co., Newark, N. J.

MISCELLANEOUS

PATENT ATTORNEYS

PATENTS. C. L. Parker, patent attorney, formerly member Examining Corps, U. S. Patent Office, McGill Bldg., Washington, D. C. Inventor's handbook sent upon request.

IS YOUR INVENTION VALUABLE? Ask A. P. Connor, electrical, mechanical engineer (ex-chief electrical engineer for New York). Patent attorney. Lawyer. Carroll St., S. E., Washington, D. C.

ENGINEERS—Do you want to utilize your exhaust steam for heating or drying purposes without back pressure on your engine? If so address Monash Engineering Co., 1417 West Jackson Blvd., Chicago, Ill.

IMPORTANT AUCTION At Vancouver, B.C., of the Contracting Equipment formerly used by the **B. C. ELECTRIC RA LWAY CO., LTD.**, Originally Costing $250,000.
On May 1st, 2nd, 3rd and 4th, 1916, by F. GRIFFIN & CO.
Including:—100-ton Baldwin Locomotive and Tender, Air Compressors, Mining Locomotives; Logging, Yarding and Stationary Engines; Hoists; Motors; Pumps; 24 Carriages and Chain Grates for Automatic Feed Stokers; 2 Lidgerwood, Panama Type, Cableways; Boilers; 40 Drills; Tunnel Bars; 25 Tons of Drill Steel; about 8,000 feet of 11-in. and 16-in. Monitor Pipe and Fittings; Carload of Woodworking Machinery.
ON VIEW 25th April to date of Sale. Catalogs now ready, apply:—
F. Griffin & Co., Auct., 448 Seymour Street Vancouver, B. C. and 311 California Street San Francisco, Cal.

FOR SALE
New 300-kw. Turbo-Generator
Curtis Turbine, G. E. Generator. Sixty-cycle, three-phase, 240-volts, Type ATB, two-pole, 3,600 r.p.m.
Has not been uncrated, and can be loaded in 24 hours.
Tennessee Extract Co. - Nashville, Tennessee

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Second Hand Equipment

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Equipment Wanted items appear at the end of this list.

ADVERTISERS' NAMES are abbreviated in most of these items. Complete names and addresses are as follows:

HOOKER Electrochemical Co., Niagara Falls, N. Y.
POWER Mchy. Exchange, 14 Morris St., Jersey City, N. J.

BELTING

50′ 8″ of 16″ double leather belt, two pieces 12″ Gandy canvas belt, 70′ and 44′ lengths, in good condition.—Smith Premier Works, Syracuse, N. Y.

BOILERS

2—90 H.P. Erie City economic type, complete.—L. F. Seyferts Sons, Inc., 437 N. 3d St., Phila., Pa.

125 H.P. H.R.T. boiler, butt strap, triple riveted, 125 lb. pressure, $375.—POWER MCHY.

High class Keeler return tubulars, 125 H.P., just as good as new.—Sergeant Glass Co., Burrows, Pa.

Six 200-hp. B & W water tube, 160-lb. McClave grates, charcoal tubes, all attachments; two 75-hp. horizontal tubular, all attachments; two 100-hp. portable 125 lb., almost new; two 50-hp. portable 125 lb., almost new.—HOOKER.

ENGINES, GAS

Westinghouse vertical, 40 hp., now running; in best possible condition. Selling because of purchase of a larger unit. Delivery immediately.—The Acklin Stamping Co., Toledo, O.

Two 25 K.W. Westinghouse 230 volt generators direct connected Westinghouse gas engines, $800 each; 12½ K.W. Crocker Wheeler 125 volt generator direct connected Nash vertical gasolene engine and switchboard, $475.—POWER MCHY.

2—14x14″, 3 Cylinder, 4 Cycle, 260 RPM, Walwrath Gas Engines, Direct Connected to 220 Volt, 85 KW Generator. These are in good running condition. 2—Turner-Frick 14x14″, 3 Cylinder, 4 Cycle, 260 RPM, Gas Engines, Shaft extended for 100 KW Generator. These engines can be inspected at our works at Sharpsville, Pa.—Valley Mould & Iron Co., Sharpsville, Pa.

25 H.P. Ohio, also 8 H.P. Ohio stationary, both excellent condition; need the room and will sell cheap.—The Vim Motor Co., Sandusky, Ohio.

ENGINES, STEAM

American Ball engine, 160 hp., 16″x14″, 250 r.p.m. with belt wheel 72″x15″, new, was never set on foundation. FS753—POWER.

14x30 Burlingame corliss, practically new, $475; 16x38 Rollins corliss, perfect condition, $500.—POWER MCHY.

1,000-hp. 160-lb. simple Porter-Allen, suitable for generator, advertised below.—HOOKER.

FANS

New cooling tower fan—1—96″ American Blower Co. heavy type, new, never used.—Municipal Electric Light Station, Henderson, Ky.

GENERATING UNITS

1 Ridgway engine, 14x14, 124 hp., and 1 Ridgway dynamo, 75 kw., 250 volts; both practically new and form a unit.—The Ford Lumber & Mfg. Co., Winchester, Ky.

Two 1040 H. P. horizontal cross compound, heavy duty, mill type Buckeye engines 24″x42x36, 120 R. P. M. each direct connected to 500 K. W., 250 volt, Westinghouse Type "Q" generators. Excellent condition, good as new. Now in operation. If interested, write for full information and prices.—Box 197, Elyria, Ohio.

50 K.W. 230 volt generator direct connected Duplex engine, American Ball make, $700; 60 K.W. 125 volt generator direct connected Ideal engine, $500; 34 K. W. Crocker Wheeler 125 volt generator direct connected Skinner engine, $550.—POWER MCHY.

We have customers who have installed larger equipment and are anxious to dispose of the following secondhand apparatus: Sturtevant Turbo-Generator, 7½ KW., D.C. 220 Volts; Sturtevant Turbo-Generator, 7½ KW., D.C. 110 Volts.—B. F. Sturtevant Co., Hyde Park, Boston, Mass.

GENERATORS

500 kw., 250-volt Burke, with pulley.—HOOKER.

WANTED

Corliss engine—One 20x42 or 22x42 simple engine of standard make and design, in first-class condition and guaranteed by seller. Give complete description. W765—Power.